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CIVIL PREPAREDNESS REVIEW

PART II

INDUSTRIAL DEFENSE AND NUCLEAR ATTACK

REPORT

BY THE

JOINT COMMITTEE ON
DEFENSE PRODUCTION
CONGRESS OF THE UNITED STATES

TOGETHER WITH

MINORITY VIEWS

AND

ADDITIONAL VIEWS

APRIL 1977

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LETTER OF TRANSMITTAL

APRIL 1977.

To Members of the Joint Committee on Defense Production:

More than a year ago, as you know, the Joint Committee undertook a comprehensive review of the nation's preparedness organizations, policies and programs, including preparedness for natural disasters, economic crises, sabotage and terrorism, industrial accidents and nuclear attacks. In the course of this review, the question of protecting our citizens and our vital economic assets against nuclear attack through passive measures again arose, as it has at different times in the past. Because of its obvious importance and its close relation to industrial production, the committee devoted special attention to this issue in its evaluation.

I believe the committee's review represents an important and timely service to the nation and should be read thoughtfully by all who take an interest in our common defense.

WILLIAM PROXMIRE, *Chairman.*

SUMMARY CONCLUSIONS

In Part I of its Civil Preparedness Review, the Joint Committee examined a range of natural and man-made threats to the life and property of American citizens, analyzing federal, state and local efforts to minimize the effects of these threats. In this portion, Part II, the committee concentrated primarily on passive protection (not involving weapon systems) of industrial and economic targets against nuclear attack, examining the feasibility and the strategic implications of this type of defense. Analysis of the many factors involved in passive industrial defense led to the following general conclusions:

1. Passive defense of industrial targets against nuclear attack consists primarily of dispersal, redundancy, and either permanent or "expedient" hardening of industrial facilities. Permanent hardening involves underground construction or other structural and engineering features, while expedient hardening involves last-minute preparations such as protecting specific items of machinery with sandbags or other materials, shutting down power or materials supply systems, and otherwise reducing fire or debris hazards. No significant improvements have been made in the technology of passive industrial defense, whereas the effectiveness of passive defense measures has been reduced through changes in strategic nuclear weapons technology, including the advent of multiple, independently-targetable re-entry vehicles (MIRVs), the Command Data Buffer System for missile retargeting, and durable sea-based missile forces. (See pp. 5–13, 16–24, 34–40, 73–86.)

2. Passive defense measures can generally be overcome by an adroit adversary, not only by applying heavier concentrations of weapons on some targets, but also by developing nuclear war contingency plans and target sets that will sharply reduce the advantages of dispersal, redundancy, and expedient measures. (See pp. 9–13, 44–54, 74–75.)

3. Aside from the technical limitations of passive defenses against strategic nuclear attack, they also pose difficult operational problems in terms of timing, weather, fallout patterns, coordination of protective operations, duration of attack, adequacy of communications, adequacy of warning, survival and availability of trained personnel, availability of power, availability of heavy-lift equipment, foreknowledge of targeted facilities, and the like. While these constraints do not totally vitiate the utility of passive defenses, they restrict its industrial damage-limiting potential in a determined attack and limit its use primarily to an option of last resort, rather than a method for assuring the survival of vital economic assets and war-making potential or for "winning" a thermonuclear war, (See pp. 16–30, 40–54, 87–88.)

4. Protection, reconstitution and support of the industrial labor force during and after a nuclear attack continue to pose difficult, although

not insurmountable, problems for post-attack industrial recovery. Solutions to these manpower problems will not alter the enormous losses in essential industrial and economic resources which can be expected in a thermonuclear attack. Solutions to these labor force problems, moreover, will be available only at very high costs, which will yield few, if any, other social benefits. (See pp. 31–33, 39, 50–51.)

5. Many of the vital economic assets of advanced industrial systems such as the United States and the Soviet Union cannot be protected by passive defenses. Examples are agriculture and transportation systems. In the absence of fully effective anti-ballistic missile (active) defenses and equally effective passive defenses, significant portions of the economic infrastructures of the United States and the Soviet Union therefore remain vulnerable to attack by each other's strategic nuclear weapons. The prospect of achieving a defensive capability effective against an adroit and determined nuclear retaliatory attack and adequate to protect all the prerequisites of major power status will continue to be a practical impossibility. Even at higher levels of passive protection than are currently projected, both countries will retain large numbers of unprotectable economic targets which are essential to their roles as major economic, military and political powers. Destruction of these targets in a thermonuclear war could (depending on the size of the exchange) severely limit or eliminate the ability of either nation to continue functioning as a world power or to protect itself from military or non-military threats, either external or internal. Apart from the loss of these critical economic resources, nuclear war could entail severe social or political disruptions that would further jeopardize either nation's domestic system and international status and make recovery a lengthy, complex and hazardous process. In view of the many vulnerabilities of advanced economic systems and the relatively low margin of damage tolerable to a major power, this economic, political and military jeopardy would exist at reduced levels of offensive nuclear forces. To adopt the view that either nation can attain the ability to "win" a major nuclear exchange, in any meaningful sense of the term, or to survive it as a major power through passive industrial defense runs the risk of encouraging potentially dangerous strategic miscalculations. (See pp. 15–16, 18–20, 54–69.)

6. The investment and other costs associated with passive industrial defense programs are high, especially if these programs include permanent hardening and additional redundancy beyond that which already exists in economies of a continental scale, such as the American or Soviet ones. Moreover, such programs will take many years to show meaningful results in the United States, since they involve extensive planning and construction. Even for a program limited solely to "expedient" techniques, there are significant planning, materials and program support costs which will require federal incentives (in the form of direct payments or subsidies, for example) and which will increase the costs of manufactured items, especially durable goods and defense articles. Incurring these costs will not lessen the number of unprotectable economic targets and may encourage an adversary to formulate target sets which avoid protected facilities in favor of unprotectable but equally vital ones. (See pp. 31–54.)

7. Adoption of a large-scale industrial protection program to defend against a nuclear attack "limited" to selected military and industrial

targets is not cost-effective, since actual targets cannot be known in advance and the cost of protecting all *possible* targets will outweigh the cost of repairing damage to *actual* targets in a nuclear exchange. Initiating an industrial protection program in the hope that a nuclear exchange will remain "limited" is again providing an adversary with incentives to strike unprotectable targets. This same consideration would apply to partial programs aimed only at protecting critical segments of industry. (See pp. 22, 51–54.)

8. In the light of the foregoing limitations on passive industrial defense, United States strategic nuclear forces remain effective against the Soviet Union, particularly in a retaliatory mode. They thus have a sound deterrent value against the initiation of a nuclear attack or similar adventure by the Soviet Union. Soviet strategic forces, although comparatively smaller and less capable against hardened targets, continue to have a high deterrent value against the United States. The outcome of prolonged nuclear exchange by these two nations continues to be their mutual termination as world military, economic and political powers and, possibly, as modern, organized societies. This circumstance, if recognized and acted upon by national leaders, is expected to keep the possibility of thermonuclear war a remote one. (See pp. 9–13, 15–30.)

9. Although limited in their effectiveness against U.S. and Soviet strategic nuclear forces, passive industrial defense measures could provide some measure of protection against less capable forces involving fewer launchers and relatively short-range weapons. (See pp. 86–91.)

10. In consequence of its own distinct strategic location and political circumstances and in consequence of the large amount of sunk investment in passive defense programs, much of it dating back to World War II, the Soviet Union is unlikely to curtail this effort, in spite of its limited utility against improved U.S. strategic nuclear forces. The prospect in the Soviet Union, as well as in the Peoples Republic of China and the Warsaw Pact nations, is for continued program growth. Any policy assessment of these programs requires consideration, not only of their relative ineffectiveness against sophisticated strategic nuclear weapons, but also of the persistent Soviet preoccupation with military defense (as opposed to offense), which arises from circumstances peculiar to the position and experience of the Soviet Union. (See pp. 86–91.)

11. Given its different strategic situation, beyond the range of all but the most advanced strategic nuclear weapons, the United States does not have the same incentives as the Soviet Union to adopt elaborate measures for defending industrial equipment against nuclear attack, particularly in view of the economic disincentives to undertaking such measures. (See pp. 12, 42–54, 89–90.)

12. Inasmuch as there does not appear to be any credible circumstance under which the rational leadership of a great power would jeopardize its position by initiating a thermonuclear war, except as an act of desperation or as a last resort, the United States should continue to make clear its longstanding intention to avoid putting other nations with nuclear weapons in desperate situations, unless the United States itself is threatened by nuclear attack. Additionally, U.S. strategic force planning should recognize that, since the option of nuclear war as a rational, calculated risk is already heavily discouraged at

existing force levels, further increments of destructive power may foster feelings of desperation in adversaries and undermine the deterrent effect these weapons are designed to enhance. (See pp. 9–13, 24–30.)

13. Evaluations of post-attack conditions and economic, social and political recovery should include fuller considerations of both the long-term and world-wide effects of nuclear weapon detonations and their possible impact on the length and viability of the recovery process. (See pp. 92–100.)

14. Even against less capable forces, the chief merit of "expedient" passive defense measures is in preserving items of heavy and already more blast-resistant equipment. If this kind of protection is desired, it can be achieved with a higher degree of effectiveness and perhaps at lower cost by stockpiling machinery in dispersed underground sites for later distribution to undamaged areas or new plant sites after a nuclear attack. This approach would be more effective against a prolonged nuclear attack and would not require the extensive on-site preparations and training that are required for "expedient" passive industrial defense. This approach would not, however, eliminate the problem of unprotectable economic assets, although stockpiling such articles as vehicles and components of refineries could reduce industrial recovery time. (See pp. 31–40, 73–81.)

15. Any initiative to increase the level of nuclear attack protection for manufacturing capacity and critical portions of the labor force requires prior consideration of (a) the probable need for this protection and (b) its overall effectiveness, as against (c) the very high cost of achieving limited protective capabilities and (d) the relative ease with which a determined attacker can overcome most protective measures. Another factor to be taken into account is the fact that the Soviet MIRV program is now beginning to gain momentum and will tend to reduce the utility of industrial hardening programs before they can be completed. (See pp. 9–13, 42–54.)

16. As between population protection and industrial protection against nuclear attack, the former represents a more manageable, although still formidable, task. The most cost-effective measures for reducing population fatalities and casualties from nuclear war are fallout shelters and strategic evacuation. Neither can hold casualties or fatalities to low levels during a prolonged series of nuclear exchanges, however, and both are constrained in their utility by the requirement for sufficient advance warning of attack to permit mass movement to relocation areas or fallout shelters. (See pp. 3, 5, 8, 81–86.)

17. Most of the fallout shelter spaces which have been identified, marked or stocked in the United States are located in urban-industrial areas likely to be the most heavily targeted in a nationwide attack on economic assets. This situation undercuts the utility of these fallout shelters. If the fallout shelter program is to be maintained as a prudential measure, it should be managed so as not to encourage a false sense of security. In particular, attention should be given to adequate maintenance of existing fallout shelters and to locating additional fallout shelters in non-urban areas. (See Part I, pp. 34–53.)

CONTENTS

I. BACKGROUND

Feasibility of Avoiding Unacceptable Damage in Nuclear War

During 1976, the U.S. intelligence community, after a five-year lapse, began once again to examine Soviet defenses against nuclear attack.[1] This reexamination gave rise in some quarters to alarm about the possible effectiveness of civil and industrial defense programs in avoiding unacceptable damage from nuclear attacks.

Relatively little public heed had been given to this issue since the early and middle 1960s, when it became evident that passive defenses (as the protection of military, industrial and population targets without weaponry is termed) could not be developed which could not be readily overcome, even by the comparatively less accurate and reliable nuclear weapons then available. During the Kennedy Administration, extensive studies of the problem revealed that no civil and industrial defense measures could be developed which, in the opinion of senior officials, would avoid unacceptable damage from nuclear weapons at an acceptable economic cost.[2] Thus, the ability of the United States to discourage thermonuclear war by promising a devastating retaliatory attack remained unchanged.

A 1963 study, for example, while suggesting that survival in some form is possible, produced these conclusions:

> Preparedness measures that would enhance the short run survival prospects of the population in the event of a thermonuclear war are of no value if the war would so cripple the nation's economic system that the survivors could not be supported in the long run . . .
>
> If measures could be devised and preparations made to assure that agriculture would not be drastically altered,

[1] Monitoring of Soviet civil defense activities was terminated after President Nixon's intelligence advisers recommended this action because of the low priority of the program and for budgetary reasons.

[2] This is not to suggest that passive defenses were discounted as humanitarian measures for reducing the loss of life or that there was total agreement about their lack of effectiveness in reducing damage generally to tolerable levels. The Kennedy Administration continued to press the Congress for funds for civil defense programs as a means of lowering fatality and casualty levels. Funds were provided for fallout shelter marking and stocking and various agencies, including the Department of Agriculture, distributed brochures describing methods for preparing basement fallout shelters. Some analysts have continued to support larger government efforts on behalf of civil defense, either for humanitarian or strategic reasons. In general, however, U.S. policy has conformed to the earlier finding that most types of passive defense can readily be overcome and funding of civil and industrial defense programs has been restricted to low levels, with the primary focus on population protection for humanitarian purposes. Industrial protection measures undertaken during the 1950s, when the primary nuclear threat was from slow-moving bombers, were terminated or allowed to fall into disuse. For some earlier studies, see "Dimensions of Survival: Postattack Survival Disparities and National Viability," RAND Corporation memorandum RM-5140-TAB, November 1966 and "Economic Viability after Thermonuclear War: The Limits of Feasible Production," RAND Corporation memorandum RM-3436-PR, September 1963. Most studies agreed that economic recovery could be feasible after nuclear attack but assumed a benign post-attack environment and required a recovery period of ten years or more.

> then it appears that all other economic problems could be managed. The cost of preparations that would provide reasonable confidence of success in achieving [economic] viability depends, of course, on the size of attack anticipated, and in particular on the weight of attack against cities and other economic targets. In very round figures, it appears that a program adequate for attacks of up to 500 megatons on cities (in as many as 100 weapons) might cost up to ten billion dollars, 2000 megatons would put the program in the multiple tens of billions, and over 3000 megatons would put it in the hundreds of billions.[3]

Even at the high projected costs (in uninflated 1963 dollars), the programs could do no more than provide for the ultimate biological recovery of the survivors; they could not protect the economy from damage that would be militarily unacceptable. Since these estimates were made, moreover, weapons have become far more numerous, far more invulnerable (permitting longer thermonuclear wars), and far more accurate, while no comparable breakthroughs have been achieved in the technology of protection.

In 1963, a group of physical and behavioral scientists assembled by the National Academy of Sciences at the request of the Assistant Secretary of Defense for Civil Defense prepared a study strongly recommending extensive passive defense measures, including construction of lengthy, interconnected grids of shelters beneath American cities and the creation of a large, full-time, and professional federal civil defense force.

The report of the Project Harbor Study was severely criticized by other physical and behavioral scientists. The primary criticisms of the report were that: (1) it did not specify the size of the nuclear attack against which the recommended shelters would be effective, (2) it failed to note that increases in offensive nuclear forces could overcome the recommended civil defense program, (3) it underrated the problems of industrial, social and economic recovery, (4) it underestimated biological damage from nuclear war, and (5) it did not recognize that the limited effectiveness of passive defenses in a large-scale nuclear war prevents such wars from being rational measures of national policy.

At the request of the Director of Defense Research and Engineering and under the auspices of the Atomic Energy Commission, the National Academy of Sciences updated the Project Harbor Study in 1967 with the help of many of the participants in the original project. The updated study contained generally the same conclusions as the original in a somewhat modified form but addressed primarily population protection in the pre-MIRV era, rather than protection of the industrial or economic infrastructure.[4]

As a result of the assessment that most defenses were very costly and could be overcome by applying more offensive weapons, certain protective measures in the United States have been discontinued. For

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[3] Sidney G. Winter, Jr., "Economic Viability after Thermonuclear War . . .," op. cit., pp. v–viii.

[4] "Civil Defense: Project Harbor Summary Report." Publication 1237, National Academy of Sciences, Washington, D.C., 1964; "In Nuclear War—Can Civil Defense Defend," "Project Harbor Controversy," and "Defense in the Nuclear Age: Project Harbor Controversy Continues," articles in the May–June 1965, August 1965 and February–March 1966 issues of *Scientist and Citizen*; "Civil Defense: Little Harbor Report," U.S. Atomic Energy Commission, Washington, D.C., 1969.

example, the National Industrial Dispersion Program and the similar food-processing industry dispersal program (established under authority of Section 2 of the Defense Production Act of 1950, as amended) were discontinued. The aim of such programs had been to disperse key industries geographically so as to present to any adversary more aim-points than his inventory of thermonuclear weapons would permit him to target.[5]

A series of studies in the early 1970s, known as PONAST I and PONAST II, reiterated the point that lives can be saved by passive defenses. For example, a "counterevacuation" program estimated to cost a half billion dollars was considered capable of reducing prompt population losses to around 23 million, while a blast shelter system costing $35 billion might reduce casualties to around eleven or twelve million U.S. citizens.

These were essentially technical studies, oriented to evacuation and shelter planning, and did not address in detail the larger questions of long-term (rather than immediate) human or property damage, the political, military or social acceptability of casualties in the 10 to 20 million range, or the questions of material damage, industrial protection and economic recovery.[6]

Throughout the civil defense debate, there has been little question that evacuation and shelter efforts could save some lives, if sufficient attack warning is provided. Agreement on this point has resulted in both evacuation and fallout shelter programs in the United States.

The larger strategic issues continue to be controversial, however. They involve not only the immediate saving of lives or reduction of illness and injury, but the long-term recovery and survival of a physically and psychically damaged population, the preservation of a viable industrial base and economic infrastructure, the maintenance of our society and its values, and the continuation of political and military power adequate to the nation's needs.

The renewal of concern among some observers for post-attack industrial recovery and population protection arose in part from changes in the character of strategic nuclear weapons and in part from conjecture about the conduct of nuclear conflicts. Among the facts which bear significantly on the problem are: (1) The dramatic increase in the number of warheads or re-entry vehicles (RVs) in the arsenals of the major nuclear powers and (2) increases in the accuracy of strategic weapons, at least of the American versions.[7] According to

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[5] Other reasons for terminating the program were that it did not succeed in breaking up the concentration of defense industries in Southern California and was less effective than natural forces in dispersing other types of industrial production capacity. See Bernard Brodie, "Strategy in the Missile Age" (Princeton: Princeton University Press, 1965), p. 208. For other government programs during this period, see "Reducing our Vulnerability to Attack," Report of the Office of Defense Mobilization to the Joint Committee on Defense Production, mimeo, May 20, 1957.

[6] "PONAST II," Proceedings of the Radiological Defense Officers Conference, Office of Emergency Services, State of California, October 1974. See also "Civil Defense in Limited War—A Debate," *Physics Today*, April 1976.

[7] A conventional measure of the destructiveness of nuclear weapons is lethality (k), which is a function of both warhead yield and weapon accuracy. The formula for deriving lethality is yield $^{(2/3)}$ divided by accuracy $^{(2)}$=k. Single shot kill probability for nuclear weapons is expressed as P_K. Damage probabilities can also be calculated using either peak overpressure in pounds per square inch or miss distance. For tables, formulae, and alternative methods of calculation, see "Physical Vulnerability Handbook—Nuclear" (Green Book), Defense Intelligence Agency, and "Physical-Vulnerability Calculations for Nuclear Weapons Using DIA Green Book Methods," by Walter C. Beckham, Lawrence Livermore Laboratory for the U.S. Atomic Energy Commission, Jan. 29, 1975.

the Department of Defense, the United States possesses an operational inventory of more than 8,900 individual warheads, while the Soviet Union can deploy in the vicinity of 3,500.[8] These numbers are substantially above those available to either nation 15 years ago, when civil defense was last a major issue. They are considered to give target planners more flexibility in selecting aim-points than was possible in the earlier period.

Another important fact bearing on the question is the 1972 signing of the Anti-ballistic Missile (ABM) Treaty. In this treaty, the United States and the Soviet Union mutually agreed to limit their active ballistic missile defenses, thereby leaving military, industrial and population targets vulnerable to the other nation's missiles and bombers.[9] Those undefended potential targets became pledges or hostages against a surprise thermonuclear attack. This treaty also had the effect of making the land-based (but not the submarine-based) strategic missiles and, to some extent, the long-range bombers of both countries vulnerable to an attack.

The advantage perceived in this posture of mutual vulnerability through ABM limitation is that every land-based missile (in addition to every invulnerable submarine-based missile) is potentially a lethal one. Neither side can hope to launch a surprise attack that would destroy any of its strategic forces at sea or all of its opponent's strategic weapons in their silos or on their airfields. Thus, the initiator of such an attack must expect severe and unacceptable damage in return and is therefore discouraged or deterred from such a high-risk and self-defeating step.

Some analysts, however, have speculated that there might be some ways to avoid at least a portion of this retaliatory damage. They have further speculated that, if such ways could be found, they might tempt a nation to try to use a perceived, unilateral advantage to "win" a nuclear war or to practice nuclear "blackmail" or "extortion" on its adversary by threatening to launch such an attack if certain demands were not met.

Thus, it is reasoned, a nation which could find some way to protect its population and its industrial capacity against the effects of superabundant nuclear weapons but without using an ABM system would have strategic leverage over its enemies. Following even a massive second-strike attack against its cities, a nation possessed of such a protective capability would, it is theorized, be in a relatively better position to continue prosecuting a conflict, if its adversary had no similar protective capacity. Such a protective capability, if it existed and if it worked, could be the cornerstone in a position of strategic "superiority" or "supremacy," according to some analysts.

While none of these observers has, as yet, provided a satisfactory reason why the Soviet Union would deny itself active defenses by signing the ABM Treaty and then turn to less effective measures such as passive defenses, the discussion has nevertheless continued.

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[8] The Soviet Union first fired a MIRV (multiple-targetable, independent re-entry vehicle) from a submarine only in November 1976. However, U.S. planning must be based on Soviet forces likely in the period 1980–85. The availability of Soviet submarine-launched MIRVs in quantity has therefore been assumed in this review.

[9] A major reason for entering into this treaty, at least on the U.S. side, was the assessment that, while a so-called "thin" ABM system might be effective against far smaller Chinese offensive nuclear forces, even a "thick" ABM system against the far more numerous and capable Soviet weapons would be hopelessly inadequate to blunt a determined attack.

One exponent of the view that a civil defense gap or 'asymmetry' could have injurious effects is Paul Nitze, who summed up this speculation in testimony before the Joint Committee by saying:

> As to the civil defense aspect, the absence of a U.S. capability to protect its own population gives the Soviet Union an asymmetrical possibility of holding the U.S. population as a hostage to deter retaliation following a Soviet attack on U.S. forces.

Elements of Passive Defense

In general terms, passive defenses are those which do not involve weapons systems (such as anti-aircraft batteries, interceptor aircraft, or defensive missiles) to limit the force of an offensive, but which instead rely on certain procedures or preparatory measures (such as the "hardening" of structures) to protect against or blunt the effects of an attack. Certain kinds of passive defenses can be prepared wholly in advance. Military or industrial facility dispersal, hardening of military or industrial facilities, and preparation of blast or fall-out shelters are among those which can be completed prior to warning of an attack. Population evacuation and "expedient" population and industrial protection measures (digging foxholes or primitive bunkers, sandbagging equipment, draining liquid distribution systems, cutting off power) are examples of passive defenses which can be carried out only upon expectation or notice of attack.[10] Even certain advance measures, such as blast shelters, require at least some early warning to be effective and the effectiveness of all passive defenses is to a large degree influenced by the amount of advance notice of impending attack.

The four major categories of passive defense are:

1. Population defense;
2. Industrial defense, including protection and support of the labor force;
3. Continuity of government throughout national territory but especially of the central government; and
4. Defense of military forces and targets (other than by active means).

Passive defenses may serve two objectives—one humanitarian and the other strategic. The humanitarian objective is to reduce the number of civilian casualties and fatalities and to provide for the welfare of survivors following a nuclear attack. The strategic objective would be to deny an attacker the ability to inflict unacceptable damage on the national economy and on the population and to preserve the economic infrastructure necessary for continuing to prosecute a war effort.

Whether serving either or both objectives, passive defenses involve activities during the pre-attack and post-attack period. Pre-attack preparedness measures contribute to the effectiveness of post-attack relief and recovery efforts.

Continuity of Government

Continuity of government programs were instituted in the United States by President Eisenhower during the 1950s. Essential emer-

[10] Herman Kahn has likened certain expedient measures to "ripping off the barn door" to provide protection against a tornado when there is no storm cellar or time to reach one.

gency functions to be performed by the Federal Government before, during and after a nuclear attack have been identified and classified under one of the following categories:

1. Essential, time-sensitive and uninterruptible functions;
2. Deferrable and non-time-sensitive functions; and
3. Functions which are deferrable until recovery.

Provision has been made for the maintenance of essential functions through federal emergency relocation centers, through the establishment of a dedicated communication system for command and control purposes, through the development of plans and policies for succession to critical federal positions (especially the presidency), through predelegation of authorities, and through preparation of such stand-by legislation, executive orders, proclamations, and departmental orders as may be necessary.

The federal continuity of government program includes some 100 or so redundant relocation centers, either hardened or dispersed in unlikely target areas. The federal relocation centers are in the Federal Relocation Arc in the Appalachian Mountains to the west of Washington or near federal regional centers or other federal sites around the country. Some of these relocation sites are primarily records centers, where information vital to emergency operations or post-attack recovery can be safeguarded. Other relocation sites, particularly the hardened or underground ones, provide operating centers for specific functions of government. One such center, for example, would coordinate the operations of the country's financial system and contains an emergency supply of currency. Designated officials and supporting staff would occupy these centers in times of high international tension or after warning of impending nuclear attack. These are in addition to hardened U.S. military command posts and alternate relocation facilities.

A consolidated federal civil emergency operating facility was developed at Mount Weather, Virginia, in the late 1950s by the Federal Civil Defense Agency, a predecessor of the current Federal Preparedness Agency. According to the latter organization, "This facility and other emergency operating facilities were designed to be used by selected Federal agencies having essential uninterruptible functions. These facilities are surveyed periodically to assure their optimum readiness for use in an emergency by management teams selected by the respective agencies." In 1975 and 1976, command post exercises were held to test the consolidated facility and the government's continuity of government plans for nuclear attack. These plans are prepared by the appropriate departments and agencies of government under the supervision of the Federal Preparedness Agency, which maintains policy control through a series of Federal Preparedness Circulars.

Continuity of government planning has also been done at the state and regional levels, with the policy guidance and assistance of federal authorities. In many states, the governors have the authority to appoint U.S. Senators, should they be killed or missing after a nuclear attack. State plans have been developed for the line of succession to important state-wide posts. Similarly, many states have prepared alternate or emergency relocation centers to preserve essential state

functions and services in time of nuclear attack. At the local level, Emergency Operating Centers are, in some cases, capable of filling this role for municipal governments.

Federal continuity of government planning, besides providing for the succession to posts in the executive branch, includes preservation of the Supreme Court function and relocation of those Members of Congress who are in line for the succession to the Presidency.

In addition, following a nuclear attack which destroyed or damaged the nation's capital, the Federal Government could be reconstituted in another, undamaged location from the personnel and resources which had been preserved during the so-called "trans-attack" period by transfer to the various federal relocation centers and emergency operating facilities. A first priority after reconstitution of the government would be a thorough assessment of damage to population, housing and the economy and implementation of relief and economic reconstitution measures.

The Soviet Union maintains a similar program concerned, in the words of the Chairman of the Joint Chiefs of Staff, with ". . . protecting political and military leadership . . ." In a January 1977 letter to Senator Proxmire, JCS Chairman, General George S. Brown, described parallel Soviet efforts as follows:

> Besides having many facilities that are dispersed and redundant, the Soviet Union began a program in the 1950's wherein important command-control-communications centers were constructed to withstand nuclear attacks. Hardened headquarters have been dispersed throughout the Soviet Union, Eastern Europe, and Mongolia. The first echelon command-control-communications centers of the Soviet Government and Armed Forces at a national level are dispersed and hardened within an 80-mile radius of Moscow.

Not all of the hardened relocation sites in the U.S. and U.S.S.R. provide adequate protection against direct hits from the more accurate, present generation weapons, however, and the effectiveness of relocation centers is in some measure influenced by the amount of pre-attack warning time.

Military planners and analysts consider that the nuclear powers have a certain incentive to refrain from attacking these relocation sites, since destruction of the central government would eliminate the possibility of negotiating the termination of a nuclear war and would leave surviving military forces deprived of central command, with grave consequences for both sides.

Passive Defense of Military Targets

Passive defenses of military targets consist primarily of hardening, dispersal, and mobility. Measures of this kind are used extensively by the United States and the Soviet Union, as they are to a greater or lesser degree by other modern military forces. In terms of nuclear war, the debate on passive defenses has turned mainly on the question of whether it is feasible to protect certain critical types of targets (such as fixed-site, land-based ICBMs) against incoming missiles and whether it is desirable from the standpoint of nuclear stability to develop missiles capable of penetrating such defenses (so-called "hard-

target killers"). This debate has in turn led to a debate over the feasibility and cost-effectiveness of making ICBMs mobile by placing them on mobile launchers in trenches connecting a series of dispersed launching sites.

The United States, for the most part, has resisted investments in additional land-based missiles because of their inherent vulnerability and because of the ease of protecting strategic nuclear forces by using submarines as launchers. In any case, the committee considered that the question of passive defense of military targets had already been extensively analyzed and lay beyond the scope of its purview.

Population Defense

In examining possible Soviet passive defense developments, the committee considered that population defense was not the central issue, since population fatalities or casualties are not a primary objective of American nuclear war planning nor the principal criterion for measuring the effectiveness of U.S. deterrent forces. As the Chairman of the Joint Chiefs of Staff explained in 1976:

> . . . our war planning takes that [Soviet civil defense] into account. We do not target population per se any longer. We used to. What we are doing now is targeting a war recovery capability.[11]

As regards U.S. programs for passive population defense, these are addressed at greater length in Part I of this report in the context of total emergency preparedness planning. In brief, following the introduction of intercontinental-range ballistic missiles as nuclear delivery vehicles, the United States abandoned the tactical, city evacuation plan which it had undertaken when the atomic threat was confined to bombers. Emphasis was placed, instead, on fallout shelters in what is now known as the Community Shelter Program. In recent years, the Defense Civil Preparedness Agency has begun, in a series of pilot studies, to reexamine the feasibility of urban population evacuation before a nuclear attack in a program known as Crisis Relocation Planning.

Industrial Defense

The primary methods of industrial defense are dispersal, redundancy, hardening and "expedient" or last-minute measures, which are undertaken immediately prior to a nuclear attack.

In its current phase, much of the debate on the stability of the nuclear balance is centered on the issue of whether industrial defense programs have the potential for permitting a nation to evade the consequences of a retaliatory nuclear attack and thereby gain "superiority" over an adversary. In view of its central interest in defense production, the committee decided to review the matter of industrial defense separately from other aspects of emergency preparedness. Related passive defense measures against nuclear attack are examined mainly in terms of their implications for the defense of the economic infrastructure of a modern world power.

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[11] Although declaratory U.S. policy has emphasized population attacks, especially under former Defense Secretary McNamara, the Joint Chiefs of Staff have consistently provided for the option of targeting enemy strategic forces, industry, or population since 1961. Advent of the Command Data Buffer System in the early 1970s permitted more rapid retargeting of nuclear weapons in response to changing conditions. This and the innovation of MIRV contributed to the change in declaratory strategic doctrine that emphasized industrial and military (counterforce) targets.

A primary question addressed herein, therefore, is whether the Soviet Union has developed or can develop a system of industrial protection that would deny to the United States the ability to retaliate with an unacceptably damaging attack, in the event it were first attacked by the Soviet Union. Other formulations of the problem, which overlooked the principal mission assigned to U.S. strategic forces, appeared to the committee to be of secondary importance.

American Deterrent Forces

Any appreciation of Soviet passive defenses, and especially industrial protection, must be based on an assessment of U.S. retaliatory capability as measured against the number, importance, and protectability of potential targets in the Soviet Union. Comparisons of force loadings (numbers of warheads or "re-entry vehicles") on both sides of the nuclear balance are ultimately irrelevant to damage calculations, since strategic offensive forces are not matched against each other in actual war plans, except possibly for fixed, land-based ICBMs. Therefore, while the United States in mid-1976 possessed 8900 active, online, separately targetable offensive nuclear warheads to the Soviet Union's 3500, the Soviet Union nevertheless had the capacity to inflict significant damage to the American economy and population.[12] Former Defense Secretary James R. Schlesinger has characterized the resulting situation as follows:

> This almost certainly will deter the deliberate initiation of a nuclear attack against cities, for it would bring inevitable retaliatory destruction to the initiator . . . I can say with confidence that in 1974, even after a more brilliantly executed attack than we believe our potential adversaries could deliver, the United States would retain the capability to kill more than 30 percent of the Soviet population and destroy more than 75 percent of Soviet industry. At the same time we could hold in reserve a major capability against the PRC [Peoples' Republic of China].[13]

Three years later, in the *Annual Defense Department Report FY 1978*, Dr. Schlesinger's successor, Donald Rumsfeld, likewise observed, "Developments of Soviet military power are impressive, but the challenge remains manageable."

The size of the U.S. retaliatory force results in great measure from the advent of MIRVs or multiple, independently-targetable re-entry vehicles, which the United States began to deploy in 1971. The ultimate justification for the deployment of MIRVed missiles by the U.S. was their effectiveness against hardened targets, primarily heavily hardened targets such as missile silos but also leadership bunkers, command posts, communications centers, and key industrial facilities. The deployment of MIRV has provided the United States the ability, if it chose to use it, of attacking all 3,000 Soviet cities and towns in the

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[12] Figures from Donald H. Rumsfeld, "Annual Defense Department Report: Fiscal Year 1977" (Washington, D.C., January, 1976), p. 44. Warheads reserved for restrike or on inactive status are not included in U.S. totals and may bring the complete arsenal to as many as 10,000 independent re-entry vehicles.

[13] James R. Schlesinger, "Annual Defense Department Report: Fiscal Year 1975" (Washington, D.C., March, 1974), pp. 4 & 33.

5,000–10,000 population range. Alternatively, the advent of MIRV, combined with greatly increased warhead accuracy and with rapid retargeting ability (through the Command Data Buffer System) permitted the United States to shift the emphasis in its declared targeting doctrine from population centers to military targets and industrial capacity, to "digging out" the most heavily hardened missile silos, command posts, and protected industries. Greater warhead accuracy, however, is not necessary for the destruction of most economic or industrial targets.

The advantage of MIRV in terms of destroying hardened targets is that it permits the attacker to reduce surplus or unnecessary destruction and concentrate destructive power more precisely and more effectively on a greater number of targets. By increasing the number of separate, small-yield warheads, the attacker can be sure that he is not laying down more destructive power on a given target than is actually required to destroy it.

By way of illustration, four 1 MT (megaton) warheads have a destructive power equivalent to that of a single 16 MT warhead. Another way of stating this is that increases in the yields of nuclear weapons do not give corresponding increases in their destructive potential. Thus, if accuracy is held constant, doubling the yield of a weapon only increases the radius of damage by one-third. As the yield is trebled, quadrupled, quintupled, the increments of increased damage radius quickly become even smaller.

The more significant implication of MIRV, however, is not only that it reduces surplus damage but that it expands the number of available warheads. In the event a single warhead should prove inadequate to destroy a given target, splitting up the force into a greater number of small-yield warheads provides a reserve force that can be used to direct a second or third warhead on any targets that are missed or are not destroyed. Given the accuracy of American missiles, however, a single warhead would be sufficient to render inoperative or uninhabitable, if not destroy, most types of hardened facilities. Although justified for the purpose of attacking hardened missile silos (and of overwhelming Soviet ballistic missile defense systems), MIRVs are ideally suited to the destruction of numerous industrial targets, even hardened and dispersed ones.[14] As former Defense Secretary Donald Rumsfeld described the U.S. capability in the "Annual Defense Department Report: Fiscal Year 1977":

> . . . we have now acquired the combinations of yield and accuracy that permit long-range delivery systems to strike at a wider range of targets, and to do so with relatively low collateral damage.

A year later, in his report for fiscal year 1978, Secretary Rumsfeld graphically illustrated that the current American lead in "hard target destruction capability" will be increased still further, if the U.S. goes ahead with planned deployment on 550 Minuteman III missiles of the MK-12A warhead (which doubles warhead yield from 170 kilo-

[14] As the U.S.S.R. continues to MIRV its strategic forces, the utility of the industrial defense programs recommended for the United States will steadily diminish, just as the rapid expansion of American MIRVs has undercut the usefulness of Soviet industrial equipment protection measures.

tons to 350 kilotons) and the NS–20 guidance improvement system (which increases accuracy).

While U.S. strategic nuclear missiles are almost completely MIRVed, similar Soviet forces are only about 20% to 30% MIRVed. Moreover, as former Secretary of State Kissinger observed in the context of the 1974 Vladivostok agreement, the Soviet Union had invested 85% of its "throw-weight" in more vulnerable land-based forces. In contrast, the United States committed only 25% of its throw-weight to vulnerable land-based forces and 75% to its strategic submarine force.

In addition, the Command Data Buffer System permits rapid retargeting in reponse to changes in the Soviet target system.

The overall effect of the great expansion of U.S. land- and sea-based forces through MIRV has been to create not one but two strategic offensive forces, one that is capable of delivering a deadly strike against key Soviet military targets and a second force that can be held in reserve to be used to decimate industrial capacity, less significant military targets, and, if desired, Soviet population centers. The existence of these two offensive forces is reflected in the 1974 changes in announced U.S. targeting doctrine, which emphasize military and industrial targets as the primary option of U.S. war plans.

The implication of Dr. Schlesinger's description of American forces cited earlier is that the surplus of reentry vehicles has permitted a counterforce capability against military and industrial targets to be superimposed on the existing countervalue capability against population centers. Thus, even if the Soviet Union were miraculously able to wipe out the American first strike force (primarily the more accurate land-based missiles), the United States would retain adequate warheads on its invulnerable missile submarines to destroy the Soviet Union as a functioning power, as well as inflict heavy damage on China.

A further implication is that the most vital part of the U.S. deterrent is its sea-based ballistic missiles with some 4,000 warheads or reentry vehicles, which provide the invulnerable retaliatory component. In assessing the relative capabilities of U.S. and Soviet strategic forces, the usefulness of land-based missiles can be discounted, since the greater accuracy combined with the vulnerability of land-based missiles constrains each side to target its ICBMs against the other's ICBMs. No matter which side initiates an attack, most land-based missiles will be eliminated from the picture rather quickly, either because they have been used up in trying to destroy the equivalent forces of the other side or because they will have been destroyed or rendered inoperative by this effort.[15]

In attempting to assess ways in which a Soviet military planner might defend against a foreign attack, the committee was further impressed by the formidable size of U.S. non-strategic nuclear forces, the so-called "theater nuclear forces" consisting of Lance and Pershing surface-to-surface missiles with warheads, ranging from 50 to 400

[15] It is the vulnerability of these land-based missiles that gives rise to strategic instability and first-strike fears on the part of both super-powers and that drives much of the strategic arms competition, as both countries seek some way out of the dilemma of ICBM vulnerability. The American advanced missile program known as MX is one such effort to overcome the deficiencies of these missiles with yet another land-based missile scheme.

kilotons, 155mm and 203mm mechanized nuclear howitzers, Talos, Terrier and Nike-Hercules nuclear-capable surface-to-air missiles with warhead yields up to five kilotons, nuclear depth bombs ranging in yield from 5 to 10 kilotons (for use primarily against submarine targets by aircraft and helicopters) fighter-bombers (F–4, F–8, F–14, A–4, A–6, A–7 and F–111) deployed on carriers and ashore and capable of delivering nuclear weapons in the 5 kiloton to one megaton range, ship-borne anti-submarine rockets (ASROC, SUBROC) with warhead yields up to one kiloton, Walleye air-to-surface missiles for use with F–4, F–111, A–4, A–6, and A–7 fighter-bombers and capable of carrying a warhead of 5 to 10 kilotons yield, and Atomic Demolition Munitions (ADM-nuclear land mines). [Honest John and Sergeant surface-to-surface missiles are being phased out.]

In Europe, the U.S. and NATO inventory of such nuclear weapons has remained steady at about 7,000.[16] The precise level of Soviet or Warsaw Pact theater nuclear forces is not known but is estimated to be about half that of the West.

While many of the theater nuclear forces are defensive only (nuclear land mines) or are of very short range (under 100 miles—Lance, Nike-Hercules, nuclear howitzers, Talos, Terrier, and anti-submarine rockets), the Pershing missiles have a range of 450 statute miles, adequate to reach any Soviet forces, supply depots, air fields and infantry, armor, or artillery staging areas that might be established in most parts of Poland, Czechoslovakia and Hungary. Nuclear-capable fighter-bombers can reach targets in the Soviet Union and form the basis of the Quick Reaction Alert Force, which can be dispersed and activated on very short warning for offensive operations against Soviet targets. In addition, the U.S. maintains about 1,000 theater nuclear weapons in the Atlantic Fleet, 2,500 in Asia and the Pacific theater, and a reserve of some 10,000 within the United States, which could be used to resupply U.S. forces abroad. Less accurate and less destructive than strategic nuclear weapons, these theater nuclear assets nevertheless pose problems for Soviet planners, who must contend with the disadvantage that American theater nuclear weapons can be delivered against targets well within Soviet territory (such as industrial sites, ammunition and resupply depots, transportation links, and troop staging areas) whereas the analogous Soviet weapons cannot reach the United States.

Furthermore, the linkage between the use of theater nuclear forces and strategic nuclear forces is strengthened by the fact that the Nuclear Operations Plan for theater nuclear forces is integrated with the Single Integrated Operational Plan for U.S. Strategic Forces, so that the two may be executed together.[17] This, it is believed, strengthens the deterrent value of both, by emphasizing to any potential attacker the spectrum of retaliation which may be expected.

As regards the future balance in strategic offensive warheads, the committee found that estimates were subject to a great deal of varia-

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[16] Congressional Budget Office, Budget Issue Paper, "Planning U.S. General Purpose Forces: The Theater Nuclear Forces" (Washington, D.C.: U.S. Congress, January, 1977), p. vii. For estimates of Soviet forces of like kind, see pp. 22–23. Soviet concern about the ability of these forces to strike targets in the Soviet Union is reflected in the persistent Soviet requests to take account of these systems in the SALT negotiations.

[17] Ibid., p. 6.

tion, depending on what assumptions were used to generate the projections. One analyst, for example, projected that by about 1990, the United States would still lead the Soviet Union in warheads—some 20,000 to 10,000. (See table.) The 1976 report on the strategic balance by the International Institute for Strategic Studies estimated that the current U.S. lead in strategic missile warheads will be narrowed only slightly by the middle 1980s.

STRATEGIC BALANCE IN 1990[1]

Launcher system	Number deployed	War heads launcher	Warheads
(a) U.S.S.R.:			
SS-19	1,012	6	6,072
SS-18	303	8	2,464
Other ICBM	180	1	180
SS-N-6-M3	544	[2] 3	1,632
Other SLBM's	256	1	256
Bombers (Bear)	100	[3] 1	100
Total Soviet warheads			10,704
(b) United States:			
Minuteman III	550	3	1,650
Minuteman II	450	1	450
Trident I	760	8	6,080
B-1 bomber	240	[4] 24	5,760
B-52 G/H	295	[5] 24	6,120
Total American warheads			20,060

[1] Joseph M. Grieco, "Paul H. Nitze and Strategic Stability: A Critical Analysis," Occasional Paper, Cornell University, 1976.
[2] MRV's.
[3] Kangeroo missile.
[4] SRAM's.
[5] 20 SRAM's, 4 bombs.

In terms of numbers of warheads, numbers of launchers, number and dispersal of launch points, survivability and lethality, U.S. nuclear forces appeared to the committee to be ample or more than ample to sustain a first-strike and provide the means for destroying a wide range of potential and militarily meaningful targets or target sets within the U.S.S.R., including a variety of critical industrial or industry-related targets, in a retaliatory strike.

In the committee's view, however, the current concern is whether either side could reduce its number of essential economic targets below a level that would mean it had denied to its opponent the destructive capacity of its strategic forces. At certain levels of warheads or re-entry vehicles, additional increments become surplus, so long as the number of essential but vulnerable economic, political, or military targets remains constant. Examination of the unprotectability of a variety of potential industrial and agricultural targets in both countries (see subsequent sections) showed that, even at levels of strategic weapons lower than those currently in Soviet and American inventories, the economic infrastructure of both countries remains exposed to unacceptable damage from the other. Indeed, there appears to be some difficulty in finding enough worthwhile targets to match the strategic offensive forces that have been deployed to date.

Committee Review

Despite a considerable number of earlier studies indicating the very limited practicality of passive defenses against thermonuclear attack,

the Joint Committee undertook to examine from several viewpoints this and similar speculations about the possibility of avoiding unacceptable damage in nuclear war. Specifically, the committee inquired into:

1. The political and economic consequences of thermonuclear war;
2. The conditions which might lead to nuclear war;
3. The technical feasibility of developing effective passive defenses against thermonuclear weapons, especially defense of the economic infrastructure; and
4. The evidence and causes for Soviet passive defense programs.

In its review of these and subordinate issues, the committee sought to concentrate on these primary questions: (a) Have Soviet passive defense programs in any fundamental way altered U.S. ability to inflict unacceptable retaliatory damage on the Soviet Union or could they do so in the future; (b) do Soviet passive defense programs suggest that the United States should increase the momentum or funding for its own nuclear attack preparedness programs; and (c) what is the likely future course of Soviet passive defense programs.

II. POLITICAL AND ECONOMIC CONSEQUENCES OF THERMONUCLEAR WAR

Survival and Victory in Nuclear War

In reviewing the contention that it might be possible to escape the worst effects of a nuclear exchange, the committee was troubled by the lack of any precise and meaningful standards—military, economic, or political—for defining what constitutes "survival" or "victory" in a nuclear war. Without such standards, it is impossible to have any means of judging the effectiveness of passive defense measures.

Many of those who have been most alarmed by the ongoing Soviet passive defense program have been, at the same time, most vague about defining these important concepts in relation to thermonuclear war. This has left the impression, intended or not, that whichever nation emerged from a nuclear exchange with more missiles, more factories, and fewer civilian casualties would automatically be survivor and victor. The implications are: (a) That to receive less damage comparatively is the same as survival; (b) that survival, even if merely biological, is the same as victory; and (c) that the only criterion for judgment is "relative damage" between the two combatants.

The "relative damage" concept of survival and victory did not seem to the committee an adequate standard for guiding national policy or strategic doctrine. Survival is a condition which must be judged against a nation's peacetime domestic life and its accustomed role in the world. Victory must be judged both qualitatively and quantitatively against the nation's objectives and aspirations and against the costs of achieving such a "victory." These are not only the standards by which nations ordinarily calculate their status or progress, comparatively and absolutely, they can also provide a quantifiable index of survival and of victory. They can, moreover, provide a standard for gauging the acceptability of nuclear war in terms of how much damage (losses) a nation is willing to undergo to secure certain goals (gains).

A realistic definition of survival for the Soviet Union and the United States would include, at a minimum, consideration of the following basic factors:

1. Retention of acknowledged great power status, including the ability to influence allies, international organizations and movements, and political and economic decisions in key areas of the world and the ability to protect the nation's own borders and overseas interests;

2. Maintenance of effective and unchalleged governmental control and order throughout the nation's territory with major cities intact and with the capacity to provide meaningful relief and recovery assistance throughout this territory;

3. Continuance of basic social institutions and values necessary for the preservation of domestic order and civility, including institutions both intangible and tangible, such as courts, schools and universities, churches, labor unions, and hospitals and other medical facilities (in the United States this would certainly include preservation of democratic Constitutional government and individual rights);

4. Provision of sufficient industrial capacity and economic strength to supply essential needs of the populace on a timely basis, to provide a foundation for recovery, to maintain an important role in the world economy in terms of both exports and imports and a healthy currency, and to continue supporting a military establishment, possibly in a continuing conflict.

The loss of or irreparable damage to any of these essential national "building blocks" would signify that the nation had not "survived" in any meaningful sense of the term survival, although individual citizens, military units, economic facilities and local governments might remain, even in fairly large numbers.

Providing an equally meaningful and realistic definition of "victory" in nuclear war posed greater difficulties. It would, of course, include survival on terms outlined above. Yet a commonsense standard would appear to be one based on a ratio of losses to gains. When the losses in a thermonuclear war outweigh the value of the objectives sought in the war, then any nominal victory must be hollow indeed. This standard has both quantitative and non-quantitative dimensions. It must go beyond mere body-counts and estimates of surviving productive capacity to address qualitative features of national existence, such as underlying social and political values. By way of example, no American would count a victory any war which cost him the basic rights, freedom and form of government guaranteed under the Constitution, any more than a Communist party official would see victory in a post-war situation that found much of Russia intact but brought an end to the Soviet regime or that resulted in the loss of one or more of the Soviet Union's restive minority "republics."

Measured against these criteria, the range of acceptable damage becomes much narrower for any nation claiming status as a global power than when measured against the vague and simplistic formulation of "relative damage." Thus, these standards provide a politically and economically more realistic index for determining the effectiveness of civil and industrial defense programs. This index, moreover, permits the inclusion of vital elements of national existence, such as the system of government and social traditions, which the "relative damage" concept ignores.

Passive Defense Measures and Countermeasures: Strategic Considerations

In the past, passive defenses have not been considered to be an effective means of thwarting heavy or sustained nuclear attacks. Effectiveness has been restricted to minimizing the damage from single attacks by small nuclear forces or to marginal reductions in the fatalities and economic devastation that would result from a large-scale and/or extended thermonuclear exchange. In the United States, debate has centered around the issue of whether the very small increments

of protection which passive defenses provide are worth the high cost of such protection. Research and development has aimed at harmonizing the incompatible objectives of reducing cost while increasing effectiveness. To date, no solution has been found to the problem of making satisfactory trade-offs between the price of protection and the value of the protection purchased, since most passive defense measures can be easily circumvented by a determined attacker. In 1957, the Gaither Panel wrote:

> The many shelter programs examined by the Panel indicate that broad protection can be provided, and that the cost varies fairly directly with the effectiveness of the program. All programs are expensive, as might well be expected, since the cost of a nationwide effort is calculated by multiplying an amount in dollars per person by the two hundred million people we will be protecting in 1966. As a natural consequence, the programs must be kept simple, even spartan, to cut down on the cost per person. Safety, not comfort, is the keyword. Last, we emphasize a common aspect of all programs: none offers absolute protection, and even with a prohibitively expensive program we must anticipate heavy casualties if we are attacked.[1]

In the intervening twenty years, the destructive power of nuclear weapons has increased several-fold, while there have been no breakthroughs in shelter construction.

Some analysts of Soviet passive defense programs have suggested, as noted earlier, that these are both low-cost and highly effective, so effective as to limit damage to acceptable proportions that would give the Soviet Union a "war-winning" capability and hence nuclear "superiority." This proposition was analyzed by the committee in terms of what would be required to achieve so highly capable a passive defense scheme and whether countermeasures existed which could overcome such a scheme.

To be effective enough to confer a "war-winning" capability, passive defenses would have to allow the long-term survival of a large portion of the population and the very rapid recovery of the economic infrastructure that both supports the populace and the national war effort.

Moreover, such defenses would have to be so effective that some economic or industrial activity could continue during a prolonged attack. The current size of the U.S. and Soviet strategic forces no longer permits the assumption that a benign environment for economic recovery will exist after an initial nuclear exchange. Worst case planning requires, instead, the expectation that surviving nuclear forces will be able to hinder or halt essential economic recovery activities.

In this connection, estimates that the Soviet Union could rebuild its industrial base in two to four years after a devastating American retaliatory attack seemed both implausible and inadequate to confer

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[1] "Deterrence and Survival in the Nuclear Age," (The Gaither Report of 1957), reprint of the Joint Committee on Defense Production, p. 29. The Gaither Committee neither examined the far more difficult problem of protecting the economic infrastructure so necessary to the long-term survival of the populace and the nation, nor did it examine measures for thwarting passive defenses. Instead, it recommended a program of fall-out shelters as a less costly and more effective alternative to blast shelters, which must be occupied at the time of attack to be effective, while fallout shelters do not. This program was later carried out.

on the Soviet Union any special military or diplomatic leverage.[2] Even if the current industrial capacity of the Soviet Union could be reached again in so short a time after an attack (which the committee's analysis did not confirm), it appeared that this would not be rapid enough to bestow any meaningful strategic advantage on the Soviet Union.

Far more significantly, however, analysis of the requirements of an effective passive defense and of the measures for overcoming such defenses did not support the conclusion that the Soviet Union could achieve a capability that would permit full recovery after a determined attack in a period as short as four years. Analysis instead revealed at least five major constraints on the effective use of passive defenses to gain a strategic advantage or bargaining leverage, as follows:

1. Inability of the initiator of a nuclear exchange to neutralize the victim's retaliatory forces;
2. Ease of overcoming passive defenses by simple alterations in retaliatory attack planning;
3. Inability of the initiator to exploit or follow-up a first-strike;
4. Low confidence in the operational reliability of offensive weapons and passive defense systems under thermonuclear war conditions; and
5. Uncertainties about timing and other critical variables.

The implications of these constraints are examined in the following sections.

1. Inability to neutralize retaliatory forces

Because of the mobility of ballistic missile submarines and, hence, the difficulty of locating, tracking and destroying them, no effective method exists for neutralizing these forces. They therefore form a retaliatory force that is invulnerable to nuclear attack. The existence of such a force preserves for the victim of a first strike the option, not merely of retaliating, but of retaliating at the time of his choosing and at targets which an adversary cannot accurately predict.

The initiator of a first strike, moreover, has no means of knowing with any precision how long a sea-based retaliatory attack can or will be sustained. As former Defense Secretary Schlesinger stated in the "Annual Defense Department Report for Fiscal Year 1976:" "Our sea-based missile force provides us, for the foreseeable future, with a high confidence capability to hold weapons in reserve." The initiator of a nuclear war must face the prospect of retaliation—unable to counter it and uncertain of its timing, length, force, targets and point of origin. It is on this certainty of retaliatory capability and on the uncertainty of effectively defending against it that the deterrence of nuclear war rests.

2. Overcoming passive defenses

The effectiveness of industrial defense, as well as of population shelters or evacuation, is critically dependent on the size, timing and

[2] See "Industrial Survival and Recovery after Nuclear Attack," Appendix 2 to "The Defense Industrial Base: Industrial Preparedness and Nuclear War Survival," Hearings before the Joint Committee on Defense Production, Nov. 17, 1976, p. 55.

targets chosen for the retaliatory or second-strike attack. Effectiveness is highest if the attack: (1) Comes all at once in a short space of time; (2) comes at the predicted time; (3) is launched only against protected and protectable facilities; and (4) exhausts the attacker's weapons inventory so that no further attacks are possible and relief and recovery measures can begin immediately.

Conversely, the effectiveness of passive defenses is seriously degraded if the attacker: (1) Spaces attacks over an extended period of time so that cities, dwellings, or factories cannot be reoccupied; (2) attacks unexpectedly (such as at night or other times when blast shelters are unoccupied); (3) chooses targets which are unprotectable or unprotected (oil refineries, dams, transportation centers); and (4) retains reserves of weapons adequate for any follow-up attacks. In the words of Defense Secretary Harold Brown, the effectiveness of passive defense depends heavily on how an attack is "configured and launched." [3]

If it is assumed that, in planning a retaliatory attack, the U.S. will act in its own self-interest, then a number of alternative attack configurations can be postulated that exploit the weaknesses of passive defense, circumventing it entirely or making its use so expensive as to be counterproductive. The primary weakness of most passive defense measures is that they can be employed only for relatively short periods of time because of:

(1) Inadequate long-term support for sheltered or evacuated populations;

(2) Reduction in population support stemming from idled industry; and

(3) Economic disruption and losses that result from shutting down key industry and transportation.

The invulnerability of sea-based missiles permits a retaliatory attack to be configured so as to outwait or outwit the use of passive defenses. For example, by withholding a large reserve of sea-based warheads, the U.S. will retain the ability to enforce a protracted evacuation and economic shut-down in the Soviet Union through the threat of an extended sequence of precision attacks, should the Soviets begin to reoccupy their cities and factories. This would pose a dilemma for Soviet leadership: either attempt to resume production and face the prospect of delayed or extended retaliation or maintain the production stoppage and commit slow, economic self-strangulation. The outcome of either choice is likely to exceed the value of any political or economic gain which the Soviet leadership set out to attain in initiating a nuclear war. The economic consequences of an extended mass

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[3] Hearings before the Senate Armed Services Committee, Jan. 25, 1977. Nearly all of the studies conceding high effectiveness to Soviet passive defense measures and analyzed by the committee assume that the U.S. retaliatory attack will be launched and configured in the least damaging way. They assume that the U.S. would employ MIRVs for population destruction, even though MIRV's are ill-suited for this purpose and are optimal against hardened targets, such as protected industry. They assume that the U.S. will disarm itself by using its entire, surviving inventory of weapons in a single attack. They aassume that the U.S. will attack only after the Soviet Union has evacuated or sheltered its people and protected its industry or will attack only when the Soviet populace has prepared and is in or near its expedient foxholes and bunkers of brushwood and earth. They assume that the U.S. attack will be aimed primarily at population and at those kinds of industrial facilities which lend themselves to protection and dispersal, rather than at the vulnerable facilities. See the testimony of T. K. Jones, "The Defense Industrial Base: Industrial Preparedness and Nuclear War Survival," Hearings before the Joint Committee on Defense Production, Nov. 17, 1976, pp. 40–41. See also the Boeing report "Industrial Survival and Recovery after Nuclear Attack," Appendix 2 to the foregoing hearing.

evacuation-manufacturing moratorium are alone enough to deter rational decision-makers from attempting to use passive defenses except as a last resort.

Under the circumstances described above, the United States, of course, would continue to be vulnerable to similar Soviet submarine attacks. The outcome of an initial nuclear exchange is thus a stalemate, with both sides heavily damaged in the process and facing the ever more certain prospect of even graver damage and the loss of major power status if further retaliatory exchanges ensue. This condition will not only tend to discourage further exchanges, it acts as a strong disincentive on both sides to initiating a nuclear attack in the first place, except under extreme provocation.[4]

Still another method of circumventing passive defenses, industrial defense in particular, would be to target only those facilities that are not susceptible of passive defense, such as railway marshalling yards, major airports, port facilities, communications centers, oil refineries, electric power generating stations, dams, canals, steelmaking plants, etc.[5] Such an attack would cripple the Soviet economy by creating bottlenecks in key areas of production and transportation and could be carried out while still retaining a reserve of weapons for use against "protected" facilities, should they be returned to operation. Attacks of this kind, which avoid population centers per se, create a special difficulty for the recipient in that, while size of the population remains constant or nearly so, the economic base for supporting it is dramatically reduced, thus increasing the internal competition for scarce resources and hampering any war effort.

3. Inability to follow up a first strike

An important, though often overlooked, fact about long-range nuclear weapons is that, while they enable their users to inflict heavy damage over great distances, they do not provide the nuclear powers with the ability to invade, occupy, and pacify the territory of an adversary after a nuclear attack. Conventional manpower, airlift, and sealift resources would still be required for this purpose. Neither the United States nor the Soviet Union commands the resources, military or otherwise, to follow up a nuclear attack on the other with an occupation force of the kind required to hold down a hostile population in a large territory for an indefinite period. This situation has important consequences for the use of nuclear weapons, since even a very successful nuclear attack cannot be exploited in the normal way.

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[4] In the event of an impasse following an initial exchange aimed primarily at vulnerable land-based forces, each side would have certain strategic advantages in contemplating further attacks. The Soviet Union, for example, would have a certain advantage in that, because of coastal concentration of industry in the United States, American industry would be relatively more vulnerable to the shorter-range Soviet submarine missiles. The United States, on the other hand, because of its larger nuclear forces and because of the generally land-locked or ice-bound nature of Soviet territory, has the compensating advantages of being able to continue attacks longer, of being able to destroy the few Soviet ports with access to the open sea, and of being able to strike Soviet targets with theater nuclear weapons surviving in Europe, the Atlantic, or the Pacific. These assymetrical advantages are of marginal significance, however, when compared with the magnitude of the losses both sides would be certain to experience if one side attempted to exploit its "advantage." A decision to try to exploit such an advantage would depend heavily on the nature of the domestic situation, the probability of negotiating a mutually agreeable termination of hostilities, the climate of desperation on each side, and the willingness of either side to risk commiting national suicide in a final nuclear conflagration.

[5] One analyst has suggested that just four surviving U.S. missiles with six MIRVs apiece could inflict unacceptable damage on the Soviet Union, if these warheads were aimed at small sets of extremely critical and vulnerable targets, such as the Soviet water diversion system. See Bernard S. Albert, "Constructive Counterpower," Orbis, Vol. 20, No. 2, Summer, 1976, pp. 343–366.

As a result, a nuclear attack or nuclear war is unlikely to lead to any permanent solution of the initiator's problems. Instead, they will likely become aggravated over the long term, as the embittered survivors seek the means of obtaining retaliation against whoever they perceive to have caused the original attack. Out of such bitterness in Germany in the aftermath of World War I came Adolf Hitler and the German war machine that led to World War II.

Political leaders and war planners must contend with the possibility that their inability to pacify a damaged adversary may create a foe far more resolute and determined in the future, making nuclear aggression unprofitable over the very long range and thereby adding to the disincentives for resorting to nuclear war that already inhibit rational decision-makers. The availability to the attack victim of surviving sea-based retaliatory forces acts even more decisively to discourage rational leaders from exercising the option to initiate an unprovoked nuclear attack.

4. Low confidence levels

An essential requirement for a hypothetical "war-winning" capability would be Soviet confidence levels of a high order in terms of the successful operation of strategic offensive systems and in terms of the successful implementation and operation of all industrial and population defense programs. In view of the fact that neither Soviet Strategic Rocket Forces nor Soviet Civil Defense units and programs have ever been tested under actual nuclear war conditions, the committee found it extremely difficult to accept the contention that the Soviet leadership would repose sufficient confidence in these untried systems to risk the entire survival of the Soviet Union as a political and economic unit, as well as the survival of the Soviet communist movement and the regime itself, on the reliability of these systems under crisis conditions.

Although advised that the Soviet Union might mistakenly consider its offensive forces and defensive measures highly effective, the committee found no persuasive documentation of either the reliability of Soviet programs or of Soviet belief in the reliability of its programs. While the pronouncements of Soviet leaders about the effectiveness of their forces (both offensive and defensive, but especially the latter) are abundant, evidence gained from interviews with Soviet citizens reveals a high degree of skepticism about the extent and effectiveness of Soviet passive defenses among both the public and civil defense officials.

It has been implied that, while Soviet leaders would not actually resort to nuclear war, they might have enough confidence to rely on their defensive programs for "bargaining leverage" in an attempt at nuclear "bluff" or "blackmail." Practically speaking, however, there is no difference in the confidence level required to threaten a nuclear attack and the confidence level required to carry it out successfully, since the Soviet leadership must always plan prudently against the possibility that the United States would again call a Soviet bluff, as it did in Cuba.

5. Timing and other uncertainties

Related to the question of confidence levels for protective programs is the issue of controlling the many variables that might be involved in deciding to launch a nuclear attack. This problem, of course, takes

on slightly different aspects, depending on the attack scenario that is assumed. All authorities are in agreement, however, that a massive "disarming" attack (one designed to eliminate all of the victim's strategic forces) is impossible because of the invulnerability of submarine-launched ballistic missile forces, which would always survive.

Two other models that have been suggested are: (1) a "national" or "economic" attack which seeks to decimate the population and/or economic infrastructure of the victim, so that it ceases to exist as a great power, no matter what strategic forces survive; and (2) a "limited" attack on selected military and/or key industrial targets, either as part of a warning or an effort to exact some kind of gain. The type of attack usually described as a means of "winning" a nuclear war involves elements of all three of these models.

Under this scenario, the Soviet Union would first evacuate urban population, implement its standby industrial protection measures, and shelter the labor force or a portion of it. Then it would try to launch or threaten to launch its land-based missiles in a disarming attack against American land-based missiles and airfields and perhaps some industrial areas or targets. It would hold in reserve its submarine-launched missiles but would position these submarines off the U.S. coast while threatening to use them against American cities, unless the U.S. restrained its own strategic submarine force.

The ability to carry out such a stratagem successfully, and hence the plausibility of the entire scenario, rests on the attacker's or initiator's ability to control a number of variables, such as timing, weather, coordination of passive defense measures, and the victim's responses.

For the Soviets, the choice of optimal times for implementing the foregoing strategy is severely limited. An immediate question is whether the Soviet leadership could instigate and orchestrate a diplomatic crisis in a way that gave it the degree of control over the timing and sequence of events necessary to a successful outcome. Beyond this, evacuation of Soviet cities during the winter months is not feasible, due both to the difficulties of sheltering and supporting large numbers of refugees during the severe Russian winters and the difficulty of preparing "expedient" fallout shelters in the frozen ground without the use of heavy equipment. The spring and early summer months are also disadvantageous for evacuation, since the foodstocks required to support the population will be depleted and the evacuation will interfere with the spring planting so vital to the weak Soviet agricultural system.

Though the autumn harvest would augment food stocks, an evacuation at this time would encounter the *rasputitza*, a season of fall rains and muddy, impassable roads that bogged down the German offensives of 1941 and 1942 and that would prevent preparation of expedient shelters, as well as most motor transport on the poor Soviet road system. (Seven out of ten Soviet roads become impassable during the *rasputitza* and during the spring thaw.) The spring and fall muddy seasons, like the winter ground frost, would also prevent the use of expedient industrial defense techniques, such as covering machinery with earth. Evacuation, therefore, is most feasible during the summer months and, even at that time, the Soviets would have to forego harvesting the late-ripening crops and rely on winter wheat harvests to offset depleted food inventories.

The local occurrence of unexpected weather conditions, such as a summer shower, could likewise affect the timing and effectiveness of evacuation and industrial defense plans in specific locations, leaving some portion of the population or of industry still vulnerable to attack. The difficulty of carrying out the stratagem imputed to the Soviets during the relatively short Russian summer and of controlling the diplomatic prelude or escalation so as to coincide with the optimum time for carrying out passive defenses suggests the implausibility of this interpretation of Soviet programs.

There are, however, still further variables that represent uncertainties for the Soviet military planners. They must reckon with the fact that any effort on their part to conduct an evacuation and undertake industrial hardening measures in advance of an attack or an ultimatum will give the United States a minimum of several days and possibly several weeks advance notice of an impending Soviet move, since both of these measures would be readily known through satellites, aerial reconnaissance, and other monitoring techniques. This is more than adequate lead-time for putting U.S. strategic forces on full alert, redeploying bomber squadrons, sending all missile submarines and other naval forces to sea, and generally taking measures to reduce the impact of a Soviet attack while enhancing U.S. retaliatory power. Soviet planners must reckon, too, with the possibility that during this period of alertness and high tension, Soviet actions may appear provocative and result either in an announced U.S. policy of "launch on warning" or a pre-emptive U.S. attack.[6] Such an attack, if carried out in the midst of Soviet evacuation and industrial protection activities, would have an even more devastating impact than during normal times.

Coordination of the various elements of first-strike attacks has always posed a number of uncertainties for strategic planners. The difficulty arises from ensuring that the offensive weapons depart from their launch vehicles at more or less the same time and arrive at their targets within the same time period. The necessity for this kind of timing stems from the need to avoid giving the victim sufficient advance notice to redeploy strategic bombers, launch his own land-based missiles or take other evasive actions. For example, Soviet land-based missiles would require longer time to reach their targets than would Soviet sea-based missiles. Warning of the launch of the land-based missiles could provide the time necessary to launch U.S. missiles and move other military targets targeted by Soviet submarines. The difficulties of achieving this kind of coordination form a primary obstacle to the launching of a fully successful "disarming" attack.

These inherent difficulties would be aggravated still further by the necessity of coordinating urban evacuation, protection of the labor force, and implementation of machinery or plant protection measures. Beyond the normal problems of coordinating the timing and implementation of such mass efforts, involving tens of thousands of individuals and heavy use of communications systems (another source

[6] "Launch on warning" describes a doctrine under which a nation would launch its vulnerable land-based forces at the earliest signs of a threatening action by an adversary, so as not to lose these strategic assets to the adversary's first strike. A pre-emptive strike is somewhat similar in that it involves attacking an adverary first on the assumption that the adversary is preparing an attack of his own. While American declaratory policy has avoided endorsing either approach, Soviet planners cannot be sure that, if made desperate enough, American leaders would not resort to such extreme measures.

of advance notice), there is the difficulty that arises from the fact that none of these offensive or defensive systems have been exercised all at once or under crisis or war-time conditions. Small anomalies or accidents, such as a premature launch of a single missile or a breakdown in a vital communications circuit or an inadvertent tip-off of Soviet plans and timing, could have devastating consequences for the whole plan.

Nor can the Soviet leadership be sure that its evacuation programs and stand-by industrial protection measures can be implemented with the efficiency and timing that a crisis-escalation schedule might call for, since these programs have only been tested on a very limited basis. They call, moreover, for discipline and cooperation among millions of people that might be difficult to achieve even in the Soviet Union.

Some American observers have stated that the Soviets could evacuate their cities and protect vital machinery in three to four days time, if all preparedness programs have been fully completed in advance, or in several weeks, if they are not. While certain Soviet manuals establish times like these as goals, there is no factual basis for believing that such extraordinarily disruptive, large-scale, and unrehearsed programs could be carried out to the extent necessary in these ideal periods.

Finally, the character of an American response to Soviet moves must remain an uncertainty of major significance to Soviet planners, even as it does to American political and military leaders, who themselves cannot know in advance precisely what course they might take in reaction to a Soviet attack or ultimatum.[7]

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The difficulties inherent in achieving the mastery of events, weather, timing, communications, etc. necessary for executing such an operationally demanding offensive attack-cum-passive defense, when combined with the severe constraints on the effectiveness of passive defenses generally, make implausible the assertion that a rational leadership would, as a premeditated act, adopt such a course of action and thereby place in gravest jeopardy a nation's economic and political survival. Nevertheless, the committee examined a range of possible circumstances under which such a course might be contemplated.

Costs, Risks and Benefits of Nuclear War Initiation

Speculation that the Soviet Union has or is seeking the ability to "win" a nuclear war through the use of passive defenses has failed to advance a cogent and plausible circumstance in which initiating a thermonuclear war would appear to be an attractive option to the

[7] A variety of possible reactions can be postulated, however, with their credibility depending on how desperate the American leadership considered the situation. For example, the U.S. might accede to any Soviet ultimatum, wait until Soviet cities or factories were reoccupied and then inflict a devastating attack on the Soviet leadership, industry, populace, and/or agricultural system, crippling the Soviet economy for decades to come. Or, an American president, following a Soviet ultimatum, might be swayed by public pressure to try a pre-emptive attack. After a Soviet first-strike, similar public reaction might end in an American arms build-up of enormous proportions or in a campaign of retaliatory nuclear attrition. Or, in the case of an ultimatum, the U.S. might simply call the Soviet bluff, posing for the Soviet leadership the dilemma of (1) following through with an unprovoked and well-advertised (and thus weaker) attack or (2) backing down and losing face. While these are not recommended U.S. responses, they are possibilities with which Soviet planners must reckon, especially if the U.S.S.R. seeks to coerce the U.S. by placing it in a desperate or untenable position.

Soviet leadership. Generally speaking, the decision to initiate a thermonuclear war could be made in three different circumstances: (a) as a calculated risk, (b) as an irrational act, and (c) as an act of desperation.

Case I: Calculated risk

A calculated decision to initiate a nuclear attack presupposes a rational leadership capable of assessing the costs, risks and benefits of such a course of action. It presupposes further a political, military, economic, or diplomatic objective of very high, even paramount, importance. Finally, it presupposes that such a rational leadership would find: (1) That the probable benefits of nuclear war outweigh its probable costs; (2) that its offensive and defensive capabilities are both highly reliable and highly controllable by central authority; (3) that the reactions of the intended victim can be very accurately predicted; and (4) that initiating a nuclear war is more risk-free and attractive than any other option for obtaining the desired goal.

When full consideration is given to the constraints that limit the effectiveness of passive defenses and to the certainty that a powerful and flexible retaliatory force will survive any first strike, it is difficult to conceive of a situation in which sober political or military leaders would conclude that the objective in initiating a nuclear war was worth more than the destruction that would be experienced in return or that a nuclear attack was a more appealing means of attaining this objective than any other option.

Such a course might be reasonable only in a situation where the Soviet leadership came to believe, rightly or wrongly, that the United States was gaining an intolerably long lead in strategic weapons which directly threatened the Soviet Union and which the Soviet Union could not overtake. In such a circumstance, the Soviet Union might consider that an immediate and devastating attack on the U.S. would be preferable to waiting until American forces had grown even stronger. Unrestrained pursuit of ever larger and more capable "deterrent" forces by the U.S. might thus create a condition of desperation for the Soviets and provide the catalyst for initiating nuclear war. This case, however, is more properly treated as one of last resort rather than as an option for normal decisionmaking.

Whether or not there might arise at some future date other circumstances that would tempt a rational Soviet leadership to contemplate initiating a nuclear war, the committee concluded that the Soviet Union would be deterred from exercising this option by several practical considerations. Briefly, these considerations are:

(1) The substantial remaining vulnerabilities of the Soviet economic and political infrastructure to unacceptable damage from the invulnerable American sea-based deterrent, even if Soviet population and industry defenses are as highly effective as is claimed;

(2) The practical difficulties of successfully implementing a major nuclear attack, a major city evacuation, and thorough protection of industrial capacity all in the same short time-span;

(3) The necessarily modest confidence rating which must be assigned to programs and systems that have never been tested under real-life conditions;

(4) The weakened bargaining position the Soviet Union would be in if, after evacuating its cities and halting or curtailing its industrial effort, the United States threatened to target any cities or industrial areas that were reoccupied; and

(5) The inability of the Soviet Union to control crucial post-attack variables, such as the character of the American response, the viability of its food supplies, the possible effects of radioactive fallout, and an environment unsuitable for economic reconstruction.

Since even a far more effective industrial defense than the Soviets appear to be capable of would not remove the many basic economic and political vulnerabilities of the Soviet Union, the committee did not consider that industrial defense in any way provided a capability that any rational leadership could consider a "war-winning" capability. Therefore the committee could find no credible or realistic scenario in which the Soviet Union would initiate a nuclear war or threaten to initiate a nuclear war as a means of achieving some Soviet objective, since there are no credible or realistic circumstances in which the Soviet leaders could believe that the risks and costs of such an option would be less than the gains.

Case II: Irrational leadership

The cost-versus-gains calculus that underlies the decisions of most political or military leaders is not applicable to leaders who have lost the power to reason or to assess their own, their party's or their nation's interests. Hence, irrational leaders, such as Hitler in his last days, are not deterred from taking high risks or from costly adventures by the consideration that such initiatives would ultimately be self-defeating. In a former age, by engaging in costly and high-risk gambles, some political and military leaders have, for very short periods of time, been able to achieve significant gains, only to have them turn just as quickly to humiliating losses or reversals.

In the nuclear age, however, this possibility of quick but temporary achievement is drastically altered by the character of thermonuclear weapons. Whereas before an irrational leader might enjoy a certain period of preeminence before the forces opposing him combined to ensure his defeat, the swiftness and destructive power of thermonuclear weapons assures that the costs of a high-risk adventure will be experienced quickly and severely.

Nevertheless, since it has happened before, the possibility of an irrational leader rising to head the government of a major world power cannot be discounted, although its likelihood is very small. In this eventuality, the enormous costs of thermonuclear warfare might not be enough to deter such an irrational leader from initiating nuclear war as a means of attaining some objective.

As Secretary of Defense, Dr. Harold Brown, has observed:

> Deterrence is, first of all, the perceived capability and intention of retaliating so as to destroy a substantial part of the population and industrial capacity of any nation initiating a nuclear attack on one-self. By this capability and intention, deterrence has the objective of preventing any such attack from being launched. One cannot be precise in advance as to how much destruction and what assurance of destruction is needed to deter. To some degree it depends on how unat-

> tractive the political decisionmaker considers the alternatives to nuclear war. Indeed deterrence is not without its risks as a doctrine because there may be some who are not rational enough to be deterred by the prospect of "assured destruction." That danger will grow as more countries obtain nuclear weapons. In addition, deterrence may fail if one or another of the nuclear powers decides irrationally that somehow circumstances are so bad that it would be better off with a nuclear war. Alternatively, one power might be convinced that it was about to be the victim of a nuclear attack no matter what it did, and that the outcome would be "better" for it should it strike first itself.[8]

Strategic analysts, political scientists, and military planners have generally been of the view that, in the nuclear age, there is virtually no effective way to deal in advance with the threat of an irrational leader, except to prevent his coming to power. In terms of its special interest in passive defenses and in the effect of industrial defense on Soviet intentions or capabilities, the committee found no suggestion that population or industrial defenses would increase or decrease the propensity of an irrational leadership to launch a nuclear attack. To the extent that the workings of an irrational mind can accurately be fathomed, it appears that the capability to protect population and the industry necessary to support a population would be entirely irrelevant to a decision to launch such an attack, since the kinds of irrationality that most frequently infects political leaders, such as megalomania, are marked by a lack of concern for human life.

In the absence of other, strong justifications for them, massive expenditures for civil and industrial defense against the low probability of an irrational adversary alone do not seem justifiable. This is especially so if an irrational adversary strikes without warning, leaving no time to implement defensive programs.

Case III: Last resort

Another circumstance in which the ordinary consideration of costs-versus-gains might not apply is that involving a desperate leader or group of leaders. If a nation were faced with threats of the direct kind, a rational but desperate leader might consider that initiating a nuclear attack, while certainly costly, would impose fewer costs or risks than alternative courses of action. As Secretary of Defense Brown has noted in the remarks quoted earlier, the ordinary forms of deterrence will not discourage a desperate leader or leadership from nuclear attack.

For example, an effort by the West to "roll back" the Iron Curtain and to "liberate" the Soviet republics or client states in East Europe might be so threatening to the Soviet regime, to Soviet communism, or to the Russian people that the initiation of a nuclear war to forestall this roll-back would appear to be the lesser of two evils. Likewise, an overt or implied threat by the United States and/or its allies to launch a direct nuclear attack on the Soviet Union might be perceived as sufficient cause to warrant the desperate step of try-

[8] Address entitled "Strategic Force Structure and Strategic Arms Limitation," reprinted in "Civil Preparedness and Limited Nuclear War," hearings before the Joint Committee on Defense Production, April 28, 1976, p. 131.

ing to implement a pre-emptive strike on the United States, no matter how costly the retaliation would be. Any strong threat to the core values or interests of a nation, therefore, is enough to upset normal calculations of deterrence and to run the risk of igniting a nuclear war no one wants by making it an option of last resort.

In reviewing various estimates of the willingness of the Soviet Union to initiate a nuclear attack or war, the committee could find no authority who believed that the Soviet Union cared to launch a nuclear attack except under conditions of extreme provocation. Most sources, in fact, considered that the Soviet Union wishes to avoid nuclear war as a matter of national policy. The views of some of the writers consulted on this issue are as follows:

> The Soviet Union has historically been a relatively prudent and sober power and I trust it will continue to be so . . . each of us possesses, and will possess for the forseeable future, a devastating second-strike capability against the other.[9]—James R. Schlesinger

> . . . the change in targeting doctrine serves to shore up deterrence across the entire spectrum of risk and consequently reduces the likelihood, which is fortunately already very low, of any outbreak of nuclear war.[10]—James R. Schlesinger

> Is the avoidance of war—particularly a nuclear war—between the two countries [U.S. and U.S.S.R.] desirable? On this question I think both sides are in agreement.
>
> This is not to say that Soviet leaders would desire to initiate a nuclear war even if they had a war-winning capability.
>
> My personal view is that meaningful reductions [in the strategic forces of both sides] are highly desirable, and that the aim of reductions should be to increase strategic stability.[11]—Paul H. Nitze

> . . . I don't believe the Soviets want a nuclear war. They will try to avoid one. I don't believe they will try to attack the United States unless they are quite sure that there is no other alternative.[12]—Thomas K. Jones

> It can be assumed with reasonable confidence that the Soviets do not necessarily desire to engage the United States in any direct military confrontation.[13]—Robert L. Pfaltzgraff, Jr.

Only in desperate circumstances, therefore, would the Soviet Union consider that initiating a nuclear war was a realistic option which overrode the normal calculations of national self-interest. To the committee, this appeared to be the only politically and militarily credible

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[9] "Annual Defense Department Report Fiscal Year 1975," March 1974, pp. 3, 4.

[10] "U.S.-U.S.S.R. Strategic Policies," Hearing before the Subcommittee on Arms Control, International Law and Organization of the Foreign Relations Committee, U.S. Senate, March 4, 1974, p. 7.

[11] "Assuring Strategic Stability in an Era of Detente," Foreign Affairs, January 1976, pp. 210, 217, 221.

[12] "Defense Industrial Base: Industrial Preparedness and Nuclear War Survival, Hearing before the Joint Committee on Defense Production, U.S. Congress, November 17, 1976, p. 48.

[13] Robert L. Pfaltzgraff, Jr. and Jacquelyn K. Davis, "The Cruise Missile: Bargaining Chip or Defense Bargain," Cambridge, Mass.: Institute for Foreign Policy Analysis Special Report, January 1977, pp. 51–52.

circumstance in which a rational leadership would fail to be deterred and would undertake a nuclear attack.

When viewed in this light, many of the questions about Soviet offensive forces and the purposes of passive defense measures take on a different meaning. The question of weapon system reliability or of attack timing become less salient, for example, because a desperate leader or a desperate nation will employ whatever means are at hand to withstand pressures that threaten core values. Population protection becomes, not a malevolent effort to achieve the impossible "war-winning" capability, but rather a prudent effort to make the devastation of thermonuclear war slightly less awesome in its consequences. Indeed, in the view of the committee, the practical difficulties of achieving even partially effective population and industrial defense and the ease with which even effective measures could be overcome make it clear that civil defense is also an option of last resort, a program no nation would rely on for survival if it were not pressured into taking desperate measures.

The policy of the United States, however, has always been to avoid making nations with nuclear weapons feel desperate. This policy is reflected in the institution of the so-called "hot-line" between Washington and Moscow, the purpose of which is to avoid mistaken perceptions of intentions during a crisis. It is reflected in President Kennedy's refusal to authorize a military strike against Soviet missile bases in Cuba in 1962. It is reflected in a series of less dramatic measures and initiatives taken by America leaders over the last 15 to 20 years to avoid any provocation or the appearance of provocation that would cause Soviet leaders to feel desperate enough to launch a nuclear attack.

Despite the official rhetoric of Soviet leaders, the committee could find no evidence to suggest that they repose sufficient confidence in their passive defense systems to think of evading U.S. retaliation. Indeed, one of the features of Soviet civil and industrial defense programs is their overwhelming orientation toward relief work rather than toward avoiding or limiting damage. No honest appraisal of Soviet civil defense programs can avoid the conclusion that their primary focus is toward coping with the extraordinary damage that nuclear attack will bring, not toward preventing such damage.

Nor could the committee find any basis for the claim that Soviet civil defense programs had any aim other than responding to a nuclear war that might be thrust upon the Soviet Union. This, in the committee's judgment, is a very different objective from attempting to promote world-wide communism by attaining nuclear superiority through uncertain, untried and partially effective civil defense programs.

Based on its evaluation of the feasibility of achieving protection of the population and of the economy adequate to evade the consequences of a retaliatory attack, the committee could not confirm the estimate made by some that Soviet passive defenses would have more than marginal, "last resort" value against U.S. deterrent forces. Nor could the committee find reason to endorse the view that these prudent if costly measures could in some way upset the strategic nuclear balance. In order to affect the nuclear balance, Soviet passive defenses would have to deny the United States the ability to inflict heavy dam-

age in a retaliatory attack. Accomplishing this would require closing the significant distance between, on the one hand, protecting *some* industrial capacity under ideal conditions and, on the other hand, preserving *most* of the economic infrastructure under any and all conditions of nuclear warfare. What is adequate to aid in the survival of isolated elements of the Soviet economy is far from adequate to provide immunity against retaliation and thereby overturn the nuclear balance by making nuclear attack seem profitable.

Inasmuch as there appears to be no realistic prospect for a complex, integrated economy to achieve this kind of total or comprehensive protective capability, the committee could see no reason for concern for the nuclear balance arising out of passive defenses.

III. PROPOSALS FOR U.S. INDUSTRIAL DEFENSE

While most recent discussion in the United States of the effectiveness of passive industrial defense has remained speculative in nature, one firm, Boeing Aerospace, has actually studied the feasibility of protecting American industry against nuclear attack. The conclusion of the Boeing study is that low-technology protective measures (as opposed to redesigning equipment and processes to withstand blast effects) offer the greatest effectiveness, at least for certain types of industrial plant equipment. Tests of some of the measures devised by Boeing engineers were conducted under a contract from the Defense Nuclear Agency in October, 1976. The results of these tests and earlier studies were made available to the Joint Committee in a Boeing report entitled "Industrial Survival and Recovery after Nuclear Attack." (See "The Defense Industrial Base: Industrial Preparedness and Nuclear War Survival," Hearings before the Joint Committee on Defense Production, November 17, 1976.)

The Boeing report suggested five areas for consideration in any U.S. industrial protection program, as follows:

1. Broader separation of industrial plants and buildings and changes in zoning codes or other regulations to foster such dispersal;
2. Development of a technology for damage-resistant building construction;
3. Establishment of a decontamination plan for radioactive areas and development of plans for obtaining and substituting labor for automated or heavy-lift equipment that would be destroyed;
4. A federal planning effort for industrial preparedness against nuclear attack and recovery therefrom; and
5. Development of plans on an industry by industry basis for protecting critical industrial equipment through low-cost, low-technology measures.

The Boeing study, which focused primarily on the last issue, estimated that advance preparation to protect industrial equipment against thermonuclear weapons would cost the U.S. $200 to $300 million to achieve protection against nuclear blast overpressures between 40 and 80 pounds per square inch (psi) and $2.5 to $3 billion to achieve protection against blasts in the range of 200 to 300 psi of overpressure.

Requirements of Industrial Defense

The Boeing study was not evaluated by the committee solely in terms of the technological feasibility of protecting certain types of industrial production equipment from nuclear blasts. Presumably, any na-

tion that wants to commit the necessary resources to such an undertaking can, to some significant degree, "harden" at least a portion of its industrial equipment. A simple and relatively low-cost technique, for example, would be to take the extensive U.S. inventory of excess, government-owned industrial production equipment, treat it with cosmoline or other preservative compounds, and store it underground in abandoned mines.

In the committee's view, however, there is a broad gulf between demonstrating the feasibility of making certain kinds of plant equipment more or less survivable and demonstrating the feasibility of protecting a significant proportion of the complex economic infrastructure that is the fundamental underpinning of a major power. Therefore, the implications of the Boeing study were also examined in terms of the programmatic feasibility of a practical and effective industrial and economic defense effort of national scope, in terms of the acceptability of such a program to the affected sectors in the economy, and the desirability, economic and otherwise, of such a program.

The appropriate measure of the effectiveness of an industrial defense program is whether it permits a nation to continue playing a role as a great power after suffering a major thermonuclear attack. Generally speaking, then, to be effective, such a program would have to be capable of accomplishing at least the following:

1. Industrial protection planning would have to be aimed at a goal of assured effectiveness (based on an estimate of the minimum industrial capacity required to support the surviving populace at a primitive level, to sustain economic recovery, and, perhaps, to continue prosecuting a conflict).

2. Industrial protection planning would have to be comprehensive across all vital industries and mandatory in nature.

3. Measures for industrial equipment protection would have to be developed which could be repealed and repeated more or less easily, as the threat of a nuclear attack waxed or waned, but with minimum economic impact in terms of lost output and productivity from shutdown and startup.

4. Measures for industrial equipment protection would have to take into account the availability of labor for carrying them out. For example, in highly automated and extremely vulnerable industries the existing labor force would not likely be adequate to carry out the myriad of steps necessary to protect such large, vulnerable, and highly complex facilities.

5. The ability to identify, mobilize, transport and support the additional labor and skills necessary to (a) increase the number of shifts at surviving plants and (b) augment the labor force per shift in surviving plants so as to offset the loss of highly automated equipment and the loss of "heavy-lift" equipment. In view of the reluctance of individuals to leave their families and home areas and in view of the competing work force requirements of local relief and reconstitution activities, this effort, like many others, would likely require considerable regimentation and coercion.

6. All industrial protection measures would have to be planned so as to minimize their provocativeness. In other words, they would have to avoid giving an adversary an additional incentive to attack because he

feared his weapons would lose their effect due to implementation of protective measures.

7. Stand-by measures would have to be designed with ease of implementation as a paramount consideration, not only to meet the requirement for rapid activation, but also to reduce the requirement for special training, equipment, or supervisory personnel.

8. Stand-by measures (disconnecting and shielding or sand-bagging of equipment, removal of fire hazards, protected storage of materials or critical components, etc.) would have to permit rapid implementation upon (at most) three days' warning of impending attack.

9. To be effective, stand-by industrial protection measures would have to be capable of at least partial or selective drills or tests on a regular basis, so as to gauge their effectiveness and determine ways of improving them.

10. Provision would have to be made for supplying adequate alternative transportation facilities and power and fuel sources for factories or industrial centers which survived, partially or wholly, but were cut off from normal power and transportation facilities.

11. Rapid development of alternative sources of critical materials and fuels would have to be provided for on the premise that, initially at least, the current foreign suppliers of such commodities would view a nation damaged in a nuclear attack as critically short of capital for these purchases and therefore a poor debt risk. (This assessment could vary considerably depending on foreign perceptions of altered national strength and world trade patterns following a nuclear exchange. In any event, prudent recovery planning could not be based on an expectation of overseas "business as usual.")

12. Special measures, distinct from those relating to the general populace, would have to be taken to protect the labor force, especially highly skilled labor, from the direct and indirect effects of the nuclear exchange. Several measures could be tried for this purpose: (a) blast shelters at plant locations; (b) blast shelters away but within walking distance of plant locations; and (c) special evacuation areas for the labor force with transportation to and from the work site.[1] The drawback of the first approach is that, where an industrial facility is directly targeted, either the plant equipment or the workers sheltered nearby or both will not survive. The difficulty with the third option relates primarily to the competition for scarce transportation resources and the increased use of scarce fuels.

13. Special measures for those extremely vulnerable but economically vital industrial facilities which cannot be temporarily "hardened" by sand-bags, metal shavings, etc. Among these plants would be: nuclear power plants, conventional power plants and substations, oil refineries, petrochemical plants (for plastics, fertilizers, pesticides, etc.), petroleum product and chemical storage and distribution facilities, ore and other material refining plants, pharmaceutical producers, and component assembly factories.

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[1] One early estimate of the cost of providing blast shelters for urban-industrial populations projected a cost of five billion dollars per annum for an unspecified but long term See Raymond D. Gastil, "Civil Defense and Arms Control Objectives," Annex II to "Arms Control and Civil Defense," prepared for the Arms Control and Disarmament Agency by the Hudson Institute under contract ACDA/IR–10, August 1963, p. 35.

Vulnerabilities of Modern Industrial Economies

A modern industrial economy such as is found in the United States and, to a lesser degree, in the Soviet Union is a highly interdependent and complex system. As one study has described it:

> The economic and social institutions which support a society's war-making capability are highly interactive; the output from one industry or economic sector can critically affect many of the other sectors, even though that output is not immediately required to sustain the final demands of the war-making.[2]

Damage to one of the elements of the system will have consequences that ripple throughout the rest of this intricate structure with a severity that depends on the significance of the damaged portion and on the extent of the damage.

An economy, therefore, can be crippled and perhaps extensively damaged for periods of time amounting to years. To quote from the same study:

> When contemplating limited nuclear strikes, it is possible to devise attacks which destroy a particular critical plant or industry, thus severely limiting, if not totally bottlenecking, the war production. The World War II example of the ball-bearing plant has been duplicated in current strategic postures, bearing in mind present-day dependence on small precision instruments and other kinds of highly critical and highly concentrated technological industries.[3]

This same study, in analyzing the vulnerabilities of the U.S. and Soviet industrial bases to limited nuclear attacks, determined that damage to certain industrial sectors could achieve the objective of "bottlenecking" an economy. These sectors were: (1) Iron and steel foundries, forging and miscellaneous products; (2) blast furnaces and basic steel products; (3) petroleum products; (4) electronic components; and (5) chemical products.[4] These bottlenecks, moreover, applied only to defense production and not to production for essential civilian needs.

Most of these potential industrial "choke points" are not susceptible of the kinds of industrial equipment protection that has been attempted in the Soviet Union or recommended for the United States, such as sandbagging or bunkering of equipment, plant dismantling and relocating, and underground or hardened construction. This stems from the fact that, in most cases, the plant and the equipment are virtually identical or inseparable. This is true of blast furnaces, petroleum and metal refining plants, and many chemical and petrochemical facilities. Sandbagging, dismantling and underground construction are restricted in their applicability primarily to manufacturing processes that involve relatively small, individual items of equipment detachable from the buildings, power supplies, and mate-

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[2] "Data Base and Damage Criteria for Measurement of Arms Limitation Effects on War-Supporting Industry," prepared for the Arms Control and Disarmament Agency by the Metis Corporation, ACDA/WEC-242, mimeo, Washington, D.C., June, 1974, p. 3.
[3] Ibid., p. 8.
[4] Ibid., p. 45 (Specific U.S. and Soviet vulnerabilities differed.)

rials transportation systems that surround and support them. Steel processing, finishing and fabricating plants, with their milling machines and turret lathes, are examples of potentially "protectable" facilities, as are electronic assembly plants.

Many of the most critical industrial processes in a modern economy are therefore the most vulnerable or least protectable. Moreover, these kinds of industries tend to be be few in number and concentrated in location, thus increasing their attractiveness as targets for nuclear weapons. In 1971, the total number of oil refineries in the United States was 247, a reduction of 39 units from the 286 refineries which existed in 1963. In 1973, there were only 68 oil refineries in the U.S. capable of processing 50,00 barrels or more per day of crude oil and these were clustered not only in close proximity to one another but close to other industrial facilities and concentrations that would make inviting targets.[5]

The greatest areas of concentration are Southern California, Gulf Coast, New York-New Jersey area, and the New Jersey-Pennsylvania area, placing these facilities near major port facilities which permits the necessary access to oil tankers but also permits attacks to be designed so as to destroy oil refining capacity, while damaging or destroying adjacent industry and port complexes. The increasing concentration of refinery capacity, as the study cited earlier points out, increases the vulnerability of this vital link in the total economy.[6]

A somewhat different situation exists in the equally vital and equally difficult-to-protect electric power industry. Here, there are far more producing units and substations and they are interconnected so as to be able to move power to stricken areas. Nevertheless, some 200 electric powerplants generate about 50 percent of the total electricity generated in the U.S.[7] Moreover, fewer than 200 cities of over 50,000 population contain about 60 percent of the population and industrial capacity of the nation and the larger power generating facilities tend to be located near these urban-industrial centers. Since it has been estimated to be virtually impossible to destroy more than 50 percent of the nation's generating capacity without also destroying an even larger percentage of the demand for power, there is little need to try to target more than these 200 major electrical power generating plants.[8] While in the 1960s such a use of the more limited arsenal of warheads may not have seemed advisable, the increase of re-entry vehicles attendant upon the advent of MIRV makes the expenditure of 200 warheads out of a pool of thousands easy to contemplate.

More recent studies indicate that, with the advent of more sophisticated electric power grids, vulnerability has been reduced in some ways. A study of the vulnerability of the electric power distribution system in the Louisiana-Southern Mississippi region concluded that:

> The analysis and evaluation reveals that a high degree of interconnection exists both within the region and with ad-

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[5] "Vulnerability of Total Petroleum Systems," Office of Oil and Gas, Department of the Interior, Washington, D.C., May 1973, p. 53.

[6] Ibid., p. iv.

[7] "Civil Defense Preparedness in the Electric Power Industry," Defense Electric Power Administration, Department of the Interior, Washington, D.C., January 1966, p. 12A. See also "Vulnerability Analysis of Electric Power Distribution Systems," Detroit Michigan, Defense Electric Power Administration, 1970, number three in the "Five City Study" of electric utility vulnerabilities.

[8] Ibid., p. 13A.

> jacent regions and, thus, only a widespread disaster could significantly affect the intraregional transmission network. However, a local system within this network can be completely disrupted. Generally, the conclusions may be stated as follows: (1) the regional electric power system can maintain its integrity when single nodes (generation) and associated links (transmission) are eliminated, (2) eliminations of combinations of components associated with a local electric power system results in reductions in regional system capacities and complete disruption of the local system.[9]

Thus, the interconnections among power systems permit the more flexible distribution of power from surviving generation plants. This capacity, while useful, does not increase the number of surviving generating stations, nor can it be utilized to greatest effect if transmission lines and substations are heavily reduced as a result of collateral damage in an industrial attack. Utility poles, for example, are "drag sensitive objects" in that they resist immediate blast pressure but not the following wind effects, which can snap off power poles surrounding the blast area.

Most power systems are interconnected through central control points. The New York-New England regional system is controlled, for example, through a facility near Schenectady, New York. An attacker possessing a large inventory of re-entry vehicles could, therefore, enhance the damage of his attack by allocating a relatively small number of warheads to the network or grid control centers. Though the U.S. electric power system has far more flexibility and redundancy than that of the Soviet Union, it nevertheless provides attractive target sets for an industry-oriented attack.

At the same time, the increasing shift to nuclear power plants provides a desperate attacker with several bonuses. Not only would a direct hit on a nuclear power plant reduce generating capacity for civilian support and industrial recovery, it would increase significantly the radioactive fallout from the blast by adding to the nuclear radiation of the warhead that of the reactor's core. If, as has been suggested, nuclear power generating facilities are constructed offshore, the fallout is increased still further, since a nuclear blast over water is the "dirtiest" type.

Generating capacity is the most difficult, costly, and time-consuming component of an electric power system to build and must therefore be considered a pacing item in any industrial recovery program. Currently, from design stage to on-line operation, it can take eight to ten years to construct a new generating plant. Under "forced draft" conditions following a nuclear attack and with performance, environmental, and safety standards totally relaxed, this lead-time could presumably be reduced. Nevertheless, there would be significant tradeoffs in terms of plant capability and flexibility of operation.

Because of the interactive or synergistic relationships in a modern industrial economy, reduction of overall productive capacity below certain levels can make recovery virtually impossible due to the lack of the necessary infrastructure base. The problem then becomes one of

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[9] "Vulnerability of Regional and Local Electric Power Systems: Nuclear Weapons Effects and Civil Defense Actions," Defense Electric Power Administration, 1975, p. v.

industrial or economic reconstruction, a far longer and more difficult process.

A 1970 study by the Stanford Research Institute estimated that:

> A total of about 800 weapons with approximately 500 MT total yield could eliminate all but a few percent of capacity in several important manufacturing sectors simultaneously.[10]

The same study concluded further that:

> Approximately 500 1–MT weapons could destroy at least 80 percent of the total MVA [Manufacturing Value Added] in each of the 71 large(st) metropolitan areas, and about half the population. At this level of damage the manufacturing capabilities of these areas might be essentially neutralized.[11]

The vulnerability of petroleum product pipelines and of electrical power generating stations was given special emphasis in this analysis, as were the difficulties of providing housing for homeless survivors in a severely damaged economy. Of particular significance in the committee's view was the fact that this was one of the first studies of post-attack industrial recovery which made a specific effort to account for the effects of the introduction of MIRVed missiles into the arsenals of the major nuclear powers:

> One possible circumstance in which the feasibility of recovery might be significantly reduced is an attack designed with the specific objective of hampering recovery. Although the studies of postattack recovery capability have included heavy urban attacks, the attacks were not generally designed to reduce selectively important vulnerable elements of the economy. The development of a MIRV capability with large numbers of small-yield weapons would greatly increase the potential for such attacks.[12]

The advent of MIRV, according to the study, suggested even smaller total megatonnage could irreparably damage the economy:

> Furthermore, many of the weapons could even be in the kiloton range. The SMSAs [Standard Metropolitan Statistical Areas] consist of a built-up urbanized area plus the remainder of the county or counties that is not really a part of the metropolitan area. More effective targeting could use megaton-range weapons to cover most of the urbanized areas. Then isolated large plants on the fringes and the small communities outside the urbanized area could be attacked with kiloton-range weapons. In this way the total yield requirement for virtual elimination of the 71 largest SMSAs could be substantially less than 500 megatons . . .
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> In general, approximately 100 to 300 delivered weapons would take out all but a few percent of the MVA [Manufac-

[10] "Potential Vulnerabilities Affecting National Survival," Stanford Research Institute for the Department of the Army, mimeo, September 1970, p. 4. See in the same series "Agricultural Vulnerability in the National Entity Survival Context" and "National Entity Survival: Measure and Countermeasure."

[11] Ibid.

[12] Ibid., p. 2.

turing Value Added] in any sector within the largest 71 SMSAs.[13]

An earlier, pre-MIRV study of post-attack recovery, while also noting the existence of potential bottlenecks and hence vulnerabilities, gave greater attention to the role of the labor force than have most such U.S. analyses:

> Since economic activity of various types is not spread evenly over the country, any given geographical pattern of destruction will in general affect some types of activity more than others. For example, petroleum refining or steel making capacity might suffer more severe destruction than other industries. Since these two industries provide essential inputs to other economic activities, there would be a tendency for output in other activities to be limited by the availability of steel or petroleum products, rather than by the availability of capacity.
>
> A similar, and probably more serious, possibility exists with respect to the skill distribution of the surviving labor force. Persons with certain types of skills and experience, particularly persons with exceptional managerial abilities, tend to be highly concentrated in a few of the largest metropolitan areas. A war in which these areas were destroyed would, in the absence of an ambitious shelter program, leave the surviving economy with a severe shortage of these skills. Also, a war resulting in the destruction of a large part of the capacity in a particular industry would be likely to kill a great number of the people who have the skills and knowledge required to rebuild that industry.
>
> Because a severe bottleneck is likely to reduce the economy's capabilities by a greater amount than would the same total destruction spread over many types of activity, the creation of such bottlenecks may be an objective of the enemy's targeting strategy. This objective was fundamental to U.S. strategic bombing strategy in World War II.[14]

The interrelationship of the economy and human welfare are described in this study in the following terms:

> By about two months after the attack, there will be a great reduction in the number of people whose survival is not assured, either because immediate threats [to health] were successfully handled, or because many people had died. At that time, the dwindling inventories of various essential commodities will signal the existence of a longer term threat to survival. Unless production of the necessities of life can be resumed, whatever success there has been in protecting the population from the immediate consequences of the war will dissipate as supplies of food, medicine and heating oil disappear; the surviving thermal generating plants exhaust

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[13] Ibid., p. 32. Note that this estimate is roughly equivalent to that made by U.S. military planners for destruction of Soviet urban-industrial centers. See page 81.

[14] Sidney G. Winter, Jr., "Economic Viability After Thermonuclear War: The Limits of Feasible Production," RAND Memorandum RM-3436-PR, The RAND Corporation, Santa Monica, Cal., September 1963, pp. 28–29.

their supplies of coal and fuel oil; and starvation, disease, and exposure take their toll.

It is at this stage that the most formidable organizational problems will present themselves. Even if the plant and equipment, the skills of the labor force, and the transportation and communications systems are fully adequate for winning the race between the recovery of output and the depletion of inventories, a failure to achieve viability could easily occur if these resources are not effectively marshalled. The plans, the authority, the effective organization, and the general overview of the situation may not exist, particularly if the nation's capital and some state capitals are destroyed in the war.

Localized attempts at constructive action are virtually certain to occur, and some may be effective in buying more time for the reorganization effort . . . But such localized attempts at dealing with the situation would not suffice to restore the economy of the nation as a whole to viability, for restoration would require the reestablishment of a system of interregional flows of goods and services. Many tasks of physical reconstruction would be beyond the resources of any local organization (in the absence of normal supplies of materials), and there would have to be some sort of national solution to the legal and financial problems standing in the way of economic activity . . .

The health and vigor of the population and the willingness and ability of the labor force to continue to engage in productive efforts will be adversely affected as supplies of the necessities of life fall to or below minimum requirements. Output will then decline, both as a result of the weakened condition of the labor force and of the inevitable rise in absenteeism as individuals attempt to meet their own and their families' needs by foraging, plundering, or selling their household goods. Ultimately, there will be a complete cessation of organized national effort toward long term reconstruction. It will become progressively more difficult to maintain order. Immediate threats of starvation, disease, and exposure will soon reappear: but there will be no inventories with which to meet these threats, no period of grace while a permanent solution is found. The result will be a catastrophe, perhaps of the same order of magnitude as the war itself. If the catastrophe is held within limits, it will be because time for further reorganization has been purchased for some portion of the population at the expense of the other portion, perhaps because some regions with relatively large food supplies will refuse to support less fortunate regions.[15]

These same themes are developed at greater length in Fred C. Ikle's examination of the relationship between social and economic factors in a post-nuclear attack situation:

Basically, the post-attack situation is determined by the resources which remain to the country as a whole. Foremost

[15] Ibid., pp. 10–11 & 13.

> in importance of course, is the size of the total national population that survives the urban attacks and escapes the possible fallout effects. Next in importance are the total food and housing left in the nation and the ability of the transportation system to bring survivors to the remaining billets and food to all the people. These are the prerequisites for the survival of the nation and of any economic or military potential. . . . havoc in the nationwide transportation system is a further reason why mobilization of armed forces and war production cannot be very effective after multiple nuclear attacks.[16]

Here again, however, the kind of attack postulated is one aimed at destruction of population, with damage to the economic system as a by-product of population attacks. If attacks are configured to maximize damage on the economic infrastructure, as innovations in nuclear weapons now permit, the leadership in a post-attack environment will be faced with the even more complex problem that results from higher levels of surviving population and greatly reduced levels of economic capacity through which to support that population. This will pose choices of the most difficult kind for national decision-makers, since any efforts to continue prosecuting a war will conflict directly with the need to sustain the population as both requirements compete for scarce, surviving productive capacity, inventories of goods, fuel and power resources, and transportation assets.

While early portrayals of the critical post-attack period between inventory depletion and output resumption may have been excessively pessimistic for their day (when nuclear arsenals were far smaller and did not permit successive nuclear exchanges), it is impossible to discount the gravity of such problems at a time when increases in the levels of separate warheads make extended nuclear war a possibility and reduce the chances of an undisturbed post-attack recovery period.

National Planning Effort

Given the many difficulties which prior analysis indicates are inherent in protecting a total economy from the effects of nuclear attack, the committee concluded that these obstacles could be overcome, if at all, only by a massive intervention by the government in the economy in the post-attack period and, more strikingly, by massive but less obtrusive pre-attack planning. While the committee had reservations as to whether even this kind of intrusion would ultimately be as effective as it would need to be, the review of a series of post-attack recovery studies strongly indicated that no industrial protection and recovery program would be viable unless centrally controlled and provided with the necessary sanctions and incentives.

National industrial defense and recovery planning would include government control of surviving resources and infrastructure and allocation of these resources to national goals, such as maintenance of the population and prosecution of the war effort. It would have to establish beforehand by law or regulation uniform industrial protec-

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[16] "The Social Impact of Bomb Destruction," (Norman: University of Oklahoma Press, 1958), pp. 181 & 190.

tion standards and methods by type of facility or industry so as to ensure the survival of the necessary capacity. Such planning would have to establish preparedness and recovery priorities between industries and within an industry. Likewise, the planning effort would mean coordinating the industrial preparedness plans and programs of various industries with a view to eliminating post-attack competition for transportation resources, fuel and power, and raw materials.

During peacetime, it would have to devise sanctions and incentives to ensure compliance with any national industrial dispersal and protection program in the pre-attack period. Planning would require analyzing the complex relationships among the many elements of the nation's industrial infrastructure and to develop preparedness and recovery plans that realistically reflected these complicated relations and links. It would have to make balanced trade-offs between various costs and risks in an industrial defense program, weighing the importance of a given plant or industry to the economy and the recovery effort against its vulnerability to attack and making generous allowances for all the uncertainties of possible attack patterns. This kind of planning would have to devise means for overcoming the differential economic impact on various firms or industries of compliance with industrial protection requirements. Finally, industrial protection and recovery planning would require developing an overall program capable of achieving all major objectives within a five-to-ten year period.

Conceptually at least, several of these national planning requirements pose no insurmountable problems. Determining those industries which are essential to civilian relief and welfare, to military needs, and to pacing recovery represents a comparatively easy task. Other requirements, however, seem far less susceptible of fulfillment. Establishing industrial protection standards for a variety of different types of plants even within the same industry would be a difficult problem; enforcing compliance with such standards would be even more so, especially in view of the fact that considerations of industrial protection against nuclear attack violate fundamental American notions of economic and legal equity. Thus, a manufacturer in a relatively isolated area might be subject to less stringent protection measures (and therefore fewer costs) while a similar manufacturer in an urban center would be obliged to take the most drastic precautions.

Once comprehensive industrial protection and recovery plans have been developed, therefore, a major barrier to effective industrial defense is thus not the development of comprehensive industrial protection and recovery plans but rather the implementation of these plans in a mixed economy and a free society.

The committee did not, therefore, find any intractable problems in the process of developing comprehensive industrial protection and recovery plans, setting aside the question of their cost or effectiveness. Yet even cursory examination of the requirements for implementing these plans reveals problems that would impact negatively on whatever effectiveness the basic plan might have. While it is clear from experience that the American people are capable of sacrifice of the highest order, it is far less clear that they would accept the great inequities that carrying out industrial defense programs would create, especially where the necessity or effectiveness of such programs remained substantially in doubt.

Economics of Industrial Defense

Besides factors bearing on effectiveness, there remain questions of economic acceptability of economic or industrial defense. No nation-wide governmental program can have any hope of success in a democracy if it is not acceptable to major segments of the society. Some of the criteria of economic acceptability which a major industrial protection program would have to satisfy are:

1. Low cost to industry and government in terms of "front end" or capital investment costs.
2. Minimum impact on productivity from new capital investment costs (as for dispersal or damage-resistant construction), from the costs of training, exercises, drills, and inspections, and from other direct and indirect costs.
3. Minimum impact on competitive edge in world trade as a result of the direct and indirect costs of industrial defense.
4. Minimum costs resulting from industrial and economic disruption if an anticipated attack is either long-delayed or does not occur.
5. Minimum regulation and additional federally mandated paperwork.
6. Minimum interference with regular peacetime manufacturing operations.
7. Minimum impact on marginal producers and firms.
8. Equitable distribution of program costs between and within industries and on the taxpayer-consumer.

Several of the effectiveness standards mentioned earlier conflict directly with the acceptability standards and several of the latter conflict with each other. For example, imposition of the costs of an industrial defense program on a marginal producer could drive that producer out of business, while exempting such a firm from the program would give him an advantage vis-a-vis his competitors.

Likewise, the requirement for low capital investment costs would appear to conflict directly with some of the measures suggested for protecting the labor force as well as the requirements for dispersing industrial concentrations, for dispersing units within manufacturing facilities, and for investing in new, damage-resistant construction techniques.

Of far greater consequence, however, is the fact that the measures which make industrial protection at least somewhat more realizable are precisely those that are the least efficient economically. The effect, therefore, of attempting to implement a nation-wide industrial defense program would be to rob American enterprise of its primary competitive advantages and return American industry to a more backward stage of development. Listed below are some of the nuclear attack disadvantages of the contemporary American industrial scene that would have to be overcome before a credible industrial protection program could be developed.

1. Large-scale industrial plants

Collocating large amounts of equipment for one industry can in certain industries enable economies of scale. The steel, electrical power, aircraft, automobile, and shipping industries are examples. About half

of the electrical powerplants in the United States produce 90 percent of the power. ("Industrial Preparedness and Nuclear War Survival," Hearings before the Joint Committee on Defense Production, Nov. 17, 1976, Boeing report, p. 119) Regarding the aircraft industry, a Boeing report notes:

> to ensure survival of unique machinery . . ., the 40-psi to 80-psi protection level would not be adequate if the machinery was located in a single building such as is the case at the Boeing Auburn (Washington state) facility. In theory, such a problem could be solved by distributing the machines among the several Boeing plants in the metropolitan area. Such distribution would provide adequate protection against low-yield weapons. The increase in production costs resulting from such a move, however, would be intolerable in the high competitive environment of the aerospace industry.

Yet this concentration makes an industrial area a more tempting target because it greatly increases the damage a given number of warheads can inflict.

2. Concentration of production facilities

Similarly, collocating equipment for several related industries enables economies by reducing transportation costs, by reducing the time needed to move products from one production stage to another, and by permitting closer contact between managements of related industries. Again, such concentration makes the industrial area a more tempting target.

3. Reliance on advanced material inputs

The aircraft industry illustrates salient points. Modern aircraft are more efficient than their predecessors. They consume highly-refined fuels with special additives; the engines use exotic alloys built to withstand extremely high temperatures; tires must use advanced materials and construction techniques to withstand great stress; the aircraft's performance and safety rely on many sophisticated instruments.[17] It would be extraordinarily difficult in a post-attack environment to build aircraft or many other products relying on the coordinated inputs of a vast range of advanced technologies. Industrial defense planning must reflect this difficulty; some plants may produce components or products that would be of no use for years after an attack and thus may not be worth trying to save in the first place.

4. Reliance on electronics

Computers, testing equipment, etc., improve productivity. Yet some electronic components are vulnerable to electromagnetic pulse and other nuclear effects without proper shielding; diagnosis of electronic equipment relies on other electronic equipment; repair of electronic equipment often requires replacing faulty components; and it may be impossible to replace these components or to rapidly rebuild the factories to build them after an attack. Thus facilities relying on electronics may well be at a comparative disadvantage in the post-attack

[17] The 1974 Metis Corporation study cited earlier ("Data Base and Damage Criteria . . .") indicates that the guided missile and space vehicle, ordnance, and electronic industries would be especially subject to bottlenecking, pp. 49–51. This study also contains a useful overview of the U.S. target planning process (pp. 4–5).

period vis-a-vis their peacetime-inefficient competitors that make less use of electronics.

5. Energy- and capital-intensive industries or plants

Peacetime industrial labor costs are very high. Substituting energy and capital often provide economically attractive alternatives. In addition, energy and capital equipment allow processes that labor cannot provide, such as economical extraction of metals from low-grade ores or creation of new chemicals. In a post-attack environment, the situation would be reversed. Energy would be scarce, and would have to be rationed to industries on the basis of their energy costs and the value to post-attack recovery of their products. Repairs to capital equipment would also have to made on a similar basis; as discussed above, the products of advanced equipment may be unusable for years following an attack. At the same time, labor would be relatively more plentiful: there would be work for every able-bodied person and the pay might easily be subsistence. Thus, plants not using the most energy- and capital-intensive techniques might be more useful to post-attack recovery than their counterparts that are more efficient in peacetime.

6. Reliance on automation

American reliance on automated production techniques, such as numerical control technology, or on advanced technologies, such as laser beams, would have to be offset in a comprehensive industrial recovery program. This could be done either by providing disincentives to the use of automation or high technology equipment (thus reversing the trend in national policy) or by requiring government or corporate reserves of non-automated, low-technology industrial production equipment as a stand-by for the post-attack period.

7. Disincentives to inventories

The high cost of maintaining inventories of finished goods, semi-finished goods, or basic materials has consistently pushed American manufacturers in the direction of lowering such inventories or backlogs, except where unavoidable or during periods of temporary short supply. The requirements of effective industrial production suggest, however, that, while uneconomic, large product inventories and materials reserves would be basic to the recovery process, providing a ready supply of needed components for reconstituting the industrial base and society and a reserve of materials to offset short-term disruptions in normal distribution patterns.

Should a peacetime industrial protection scheme be developed for the United States, this tension between American economic efficiency and the post-attack recovery capability, like the inequities of implementation, would have to be resolved by additional private investment or by government subsidies. The ultimate premium for this type of insurance policy would, of course, be borne by the taxpayer-consumer.

Evaluation of Industrial Protection Recommendations

While there is much commonality between preparedness for peacetime disasters and preparedness for protecting civilians in nuclear war, there is a very little commonality between peacetime industrial

disaster preparedness and industrial defense against nuclear attack. This has profound implications for the feasibility of industrial defense and post-attack recovery.

The Boeing Aerospace Company has performed useful, and possibly unique, studies of industrial defense. Working in part with company funds, Boeing engineers sought to determine the feasibility of developing and implementing industrial protection measures for the Boeing factory complex at Auburn, Washington. They found that, for these factories, the central problem was to protect heavy machine tools from nuclear-induced effects (i.e., blast, ground shock, fire, and collapsed buildings). They reasoned that the buildings would offer little resistance to nuclear blast and could not be strengthened to do so. However, they pointed to several World War II experiences in which equipment was used with makeshift shelters, or even without shelter, with little loss or even gain in productivity. They studied Soviet manuals for clues to developing protective methods and found that several Soviet techniques were quite applicable at Boeing with slight modifications. In particular, by placing heavy equipment on shock-absorbing material such as styrofoam blocks, wrapping it in plastic, covering it with crushable material such as plastic chips or metal shavings, and covering this all with a thick layer of dirt, they found experimentally that the equipment would survive extremely high blast pressures, and presumably would survive fires and falling debris. Such measures, they argued, would be of great value to American post-attack recovery.

Nevertheless, in its data and recommendations, the Boeing study tended to oversimplify many of the real challenges of developing an industrial protection scheme adequate or effective enough to prevent unacceptable damage to a modern economy. In order to have a balanced picture of the requirements of industrial defense as a basis for policy-making, some of the major difficulties and costs left unaddressed or simplified in the Boeing study were reviewed by the committee.

1. Limitations on effectiveness of expedient measures

While quantitatively impressive as far as it went, the Boeing study did not address crucial qualitative issues, such as the interrelationships among the factors of production, the regulatory and administrative requirements for industrial protection programs, or the economic implications of such programs, including their differential impact on various sectors and levels of industry. Intentionally or not, the study defined the problem of industrial defense in a manner that was optimal for the recommended solutions, i.e., industrial dispersal and expedient protection of items of heavy machinery.

Having demonstrated the effectiveness of such measures, the report appears to assume that, because some machinery found in defense plants is capable of being protected, the entire economic infrastructure is similarly susceptible of protection at something like the same cost with something like the same methods. No evidence or analysis was adduced to support this assumption or extension of the original premise. Nor could the committee, in its analysis of the problems of industrial protection, find any evidence that tended to support this conclusion. On the contrary, analysis of other studies of the problem strongly suggested that the recommended measures for equipment pro-

tection were limited in their applicability primarily to heavy or durable pieces of equipment, such as that found in machine shops, blast furnaces, foundries, and steel fabricating plants.

Of course, some industries are inherently vulnerable to nuclear attack; examples of such industries are those with many internal distribution systems such as conveyors or pipes feeding material from one process to the next (chemical plants, including petroleum refineries); transportation facilities having vulnerable points (airports, shipping ports, and railroad bridges, tunnels, and yards); and power industries relying on large facilities (nuclear power plants, oil- or coal-burning generators, hydroelectric dams).

The difference between protecting or preserving heavy equipment items and defending an entire, integrated industrial production system appeared to the committee to be of considerable significance, since it is upon this total system and not upon individual pieces of equipment that the economic base of a great power rests. Moreover, if ancillary services and systems such as power and materials distribution systems are lost, even the survival of heavy equipment will not guarantee a base for recovery of industrial production capacity.

The committee was further impressed in its evaluation by the fact that the report did not address precisely those types of industrial facilities which would be most likely to be chosen as targets simply because of their great vulnerability to single reentry vehicles. For a would-be attacker, of course, the problem of overcoming the effects of such industrial defenses is relatively easy: he needs only to select those vital targets which are incapable of being protected or hardened by expedient or any other measures. As noted earlier, targets falling into this category would be: ports, canals, dams, conventional and nuclear power plants, railroad marshalling yards, air terminals, communications centers, oil refineries and storage depots, petrochemical plants and storage facilities, food-processing facilities, materials refining plants, electronics manufacturers, and other component assembly plants.

The effect of adopting an industrial defense scheme which applied only to a restricted portion of the broader universe of industrial facilities would be to influence an adversary to remove these "protectable" plants from any putative target list while reallocating warheads to the vulnerable targets. The investment and other costs of hardening the already more blast-resistant facilities or equipment would be, in effect, lost and the value of the protective measures would be largely negated, since the economy would still be decimated and with it the vulnerable plants and equipment needed to support the heavy equipment facilities.

In sum, the kinds of low-cost, low-technology expedients recommended by the Boeing study as a basis for development of defense measures on an industry-by-industry basis do not appear to have the widespread applicability or effectiveness that has been suggested. Any effort to plan for the protection of the U.S. economy against unacceptable nuclear attack damage must therefore be far more wide-ranging in surveying feasible and effective measures for the protection of industrial facilities.

The recommendation for the development of a decontamination plan for radioactive areas and of a labor substitution plan for offsetting

equipment losses, on the other hand, appears to be far more susceptible of achievement, assuming the availability of adequate labor for the latter purpose, as well as only moderately competitive requirements for such labor for skilled work. The armed services and the civil defense organizations of the U.S. government have, over the years, developed a variety of stand-by or expedient decontamination techniques for both individuals and large structures, including ships at sea. Within specified time periods after exposure and up to certain levels of radiation, these measures would be effective in areas and facilities of modest size where radiation contamination was not pervasive. The costs of developing such plans, and even of their implementation, would not be high and could be reduced by advance preparations.[18] It must be recognized, however, that decontamination of large areas or plants heavily subject to radioactive fallout would probably be impractical after a nuclear attack due to the competition for resources (personnel and materials) for more urgent relief activity. The value of decontamination and labor substitution planning, however, is heavily dependent on the effectiveness of more problematic industrial defense measures.

2. Constraints on long-term protective measures

Measures recommended in the Boeing study that would require longer periods, perhaps decades, to implement include development of damage-resistant construction techniques and zoning changes to promote dispersal of industrial production facilities. As to the first, there are available now a variety of techniques for improving the damage resistance of buildings and other structures; many of these techniques have been developed as a consequence of improvements in building materials, methods, and designs or as a direct result of efforts to harden military facilities. While additional research and development would no doubt improve on this technology, the constraint is not so much technological as economic. The end of research should therefore be the development of a technology for damage-resistant construction that minimizes the cost increases now inherent in such construction.

Creation of a low-cost technology for damage-resistant construction is likely to be difficult. More difficult, however, will be imposing damage-resistant construction requirements on all new industrial construction, even if the cost increases over conventional construction are held to a minimum. Given the reluctance to date of most firms to adopt adequate safety and protective measures voluntarily, even protection against common hazards, such as fire or explosion, it is unlikely that such a program could be implemented without federal construction subsidies or, at a minimum, federal construction loan guarantees.

Changes in zoning codes and other regulations to foster dispersed industrial construction would impose similar economic burdens and perhaps even greater administrative penalties. Dispersal has two aspects. One is the dispersion of entire plants or industrial complexes away from the current urban-industrial concentrations. Given the costs of such an enterprise, the current redundancy of U.S. industry, and its

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[18] For an example of an American industrial emergency preparedness plan for nuclear attack, see that developed by Detroit Edison, "Emergency Preparedness Progress in the Electric Utility Industry," Defense Electric Power Administration, 1973, pp. 8–18. No decontamination of personnel or facilities is provided for but "individual monitoring and frequent relief" is expected to hold personal exposure within "permissible limits."

relative dispersal as a result of economic factors, this kind of dispersion seems unlikely to pay defense dividends proportional to its costs. Nevertheless, should it be undertaken again as part of a national industrial protection scheme, it will probably not succeed as a voluntary program. Again, firms will have to be offered tangible incentives to relocate large facilities and to bear the costs of siting them in places that are relatively less advantageous economically. Some types of facilities, of course, cannot be relocated at all.

The other aspect of dispersion is the disaggregation of separate units within a given industrial plant or complex, so that a direct hit by a small-yield nuclear weapon on one component will leave the other components undamaged or relatively intact. This, too, imposes economic burdens on firms in the form of additional real estate costs, additional construction costs, intra-plant transportation costs and the like. It will probably also necessitate significant changes in industrial design which hitherto have aimed at the optimum efficient disposition of stages of a given industrial process. Hidden costs may thus be involved in arranging parts of industrial facilities distant from one another in a less than efficient pattern. It appears that the greater part of the costs of this kind of dispersal will also have to be borne by the government (but ultimately by corporations and private citizens) if it is to be adopted on a meaningful scale. Here again, there are certain types of industrial plants that cannot be disaggregated except at intolerable cost.

A still more formidable hurdle lies in the fact that zoning and other land-use rights are reserved primarily to local government in the United States. It is unlikely that one locality would adopt "defensive" zoning codes or other regulations that entail economic burdens for firms and risk their movement elsewhere unless all surrounding localities simultaneously adopted similar measures. Indeed, such measures would have to be adopted virtually nation-wide, if piecemeal adoption is not to lead to havens for firms not desiring to bear the costs of defensive dispersion. This suggests that this kind sanction in favor of industrial disaggregation would not be possible without federal intervention, either through a national industrial defense zoning code or through the subsidy programs mentioned above or both. Experience thus far with compliance with regulations governing environmental and occupational safety protection is not such as to breed optimism about the acceptance of additional plant-oriented regulation and zoning, at least not in the absence of large federal subsidies. Federal support may also be required for communities that lose jobs and revenues as a result of new zoning or plant regulations intended to disperse industry or plants.

These programmatic implications and costs of industrial dispersal and damage resistant construction were not considered in the Boeing study yet must figure in any comprehensive evaluation of the costs, benefits, risks and feasibility of industrial protection.

3. Constraints on implementation

The effectiveness and the low costs ascribed to expedient industrial protection measures depend heavily on adequate and certain warning of an impending nuclear attack. Even if a factory has developed a

plan, trained personnel in its implementation and stockpiled the necessary supplies, the plan would take appreciable time to put into effect. The Boeing report notes:

> If all advance preparations called for in Soviet plans were complete, they could transition into a war-ready posture in 3 to 4 days. If advance preparations are incomplete, it could take a week for complete dispersal and evacuation of their population and up to several weeks to achieve full protection of their industrial machinery.

Based on the committee's review of the requirements for even partially effective industrial defense, these execution estimates seemed excessively optimistic. While urban evacuation, under ideal conditions, might be accomplished in as little as three days, there does not seem to be any realistic basis for assuming that measures for protecting industry could be completed in so short a time, even if advance preparations had been fully implemented, because of the simple logistical magnitude of the process of burying hundreds of thousands of pieces of equipment under layers of plastic sheeting, metal shavings and earth and taking related measures. Then, too, efforts to conduct an orderly urban evacuation simultaneously with the shutting down and protecting of industrial equipment would entail enormous strains on the administrative system, as well as engender conflicts and divisions, even in a highly regimented society. The longer lead-times doubtless required for the implementation of industrial protection measures, of course, lengthens the warning and response time available to the intended adversary, thus minimizing the surprise or 'ultimatum' value of industrial protection.

Perhaps more importantly, if the assumption of adequate advance warning is relaxed, most expedient measures and many, more permanent precautions (which also require some lead-time to put into effect) are robbed of much of the effectiveness they may otherwise have. If a nation expecting attack misreads its opponent's signals or delays too long the decision to execute protection programs or decides that an attack is not forthcoming, advance preparation for these programs will avail nothing. If, on the other hand, it acts too quickly, it faces the prospect of giving its enemy a strong incentive to attack quickly or the prospect of a prolonged and perhaps unnecessary disruption of vital industrial production, as well as of other services. Knowing the dependency of industrial protection measures on advance warning, a determined adversary can exploit the inherent advantage of the offense in the timing and configuration of its attack (by attacking at night, for example, or by targeting facilities least subject to protection or requiring the longest time to protect).

What remains highly uncertain for the attacker and for the victim is knowing that precise moment when to order execution of population and industrial protection measures. This problem is considerably simplified for a desperate leadership attacking as a last resort. Yet it poses questions both delicate and grave for all but the desperate, since to wait until enemy forces are readied is to wait too long, while a premature decision has equally serious consequences. In any case, it is doubtful that an escalating crisis will provide warning of the exactitude and the certainty that is optimum for the most effective execution of

civil and industrial defense measures, yet their adequacy is highly contingent on such exactitude and certainty.

4. Consideration of the labor force

While noting the primary importance of the labor force to industrial recovery in the post-attack period, the Boeing study did not explore either measures or costs for protecting the labor force from initial or successive attacks, beyond recommending on-site blast shelters and the establishment of a decontamination plan for radioactive areas.

The problem of preserving the labor force is one of major proportions; it changes in complexion as a nuclear attack progresses. In the pre-attack phase, the work force, or a significant portion thereof, will be required at plant sites to carry out expedient protection measures. During the trans-attack period, the labor force will have to be protected, either through blast shelters or evacuation to safe areas. In the post-attack period, the labor force will have to be at the surviving plant site for recovery work but may not be able to remain there for long periods because of lingering radiation or because of the difficulty of supporting the workers in damaged areas.

Solutions to the problems of preserving the labor force in one period are often not appropriate for another period. After carrying out expedient measures, the work force can either resort to adjacent blast shelters or be evacuated to distant safe areas. (A miscalculation about the timing of the attack or its termination would, of course, be fatal to much of the work force.)

The construction of blast shelters at the plant site (an approach which the Soviets appear to be adopting) has the defect that a direct hit by a nuclear weapon could "dig out" all but the most heavily hardened (and therefore expensive) blast shelters. Those that were not thus destroyed could be rendered uninhabitable by a direct hit, forcing the evacuation of the workers into high fallout concentrations. Should the workers nevertheless survive, it is clear that the direct hit would destroy any equipment or plant facilities, thus reducing the immediate usefulness of the survivors. Where plant sites and adjacent blast shelters were not directly targeted or hit, the work force would probably survive in large numbers anyway, even in the absence of blast shelters. Moreover, depending on the nature of the attack, workers may have to remain as long as two weeks in shelters before the effects of radioactive fallout will permit their safe emergence.[19]

Soviet shelters do not appear to provide for sojourns of this length and shelters capable of sustaining life for such a period would be far more costly than alternative measures. Even if blast shelters capable of sustaining life for this period were developed and built, studies conducted during the 1960s, privately and by the armed forces, on the effects of prolonged shelter confinement indicated a strong potential for group and individual break-downs which would impair the effectiveness of the laborers when they were able to emerge.

Alternatively, plans could be made to evacuate the labor force at the point when industrial protection measures have been completed

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[19] Arthur A. Broyles and Eugene P. Wigner, "Civil Defense in Limited War—A Debate," "Physics Today," April 1976, pp. 55–56. In the U.S., public fallout shelters are not equipped for long stays but some company shelters in the electric utility industry are stocked for fourteen-day occupancy; see "Emergency Preparedness Progress in the Electric Utility Industry," op. cit. pp. 17–18.

but before an attack commences. This would probably necessitate planning for, in essence, two evacuations—one of the general populace and one of the labor force, which would begin after the general evacuation but would be completed by the same deadline. Separate assembly areas and support arrangements would have to be provided for the labor force, so as to permit its ready return to surviving factories and to ensure that it was sustained at a level commensurate with extended work shifts when radioactivity levels are considered safe enough, at least for stays of relatively short duration. Presumably, in such a case, priority on transportation assets would be given to the labor force, to the extent that such priorities would be observed or could be enforced. Retaining the labor force in assembly areas separate from their families would also present difficulties.[20]

A third option would involve both blast shelters and evacuation. In this case, blast shelters would be provided for the labor force near but not within the industrial facilities themselves, so as to avoid both the need for a separate evacuation and the vulnerability that on-site blast shelters entail. These blast shelters might be constructed outside of industrial sites or areas but within walking distance of them, so as to permit ready access while avoiding additional burdens on scarce transportation facilities. Such blast shelters would not necessarily require the same degree of hardness as those located at plant sites themselves.

A final consideration in the protection and support of the industrial labor force is the question of providing for the additional shifts that will likely be required to achieve maximum output from surviving industrial facilities. Assuming that blast shelters or other measures house only one shift, plans will have to be made to assemble and sustain additional workers near the surviving plants so as to permit two or three shifts for recovery purposes.

The relative merits and difficulties, the costs, and the trade-offs among possible solutions to the problem of preserving the labor force during a nuclear attack requires more careful and detailed study before any realistic conclusions can be drawn as to the availability of effective means for accomplishing this task.

5. Adequacy of cost estimates

Because the cost projections in the Boeing report for protecting heavy industrial equipment did not encompass (1) protection of the labor force, (2) measures for defending vital industrial and related assets other than heavy machinery, (3) dispersal of industry and of plant components, (4) the hidden costs of uneconomical production systems, and (5) various subsidy programs required to promote industrial defense, the committee considered that the $3 billion upper cost estimate was excessively low. In the absence of any knowledge of how other, more vulnerable but equally vital economic assets could feasibly be protected, any meaningful estimate of the total cost of an industrial defense scheme appears impossible.

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[20] The nuclear attack plan of Detroit Edison ("Emergency Preparedness Progress in the Electric Utility Industry," op. cit., pp. 14–18) calls for skeleton crews during periods of international crisis and provides stocked company fallout shelters. No provisions are made for that portion of the labor force not on duty at the time of the attack. Purchasing agents at the company's Emergency Operations Headquarters are to acquire necessary equipment, transportation and supplies from outside the company but how this will be achieved is not determined.

Examination of possible methods of protecting the intrinsically more vulnerable facilities indicates that the so-called "expedient" measures employing anti-corrosion compounds, plastic sheeting, and other supplies would be inadequate and only completely hardened or underground facilities would be proof against nuclear attack. Even these measures could not be applied to certain vital factilities, such as transportation facilities and terminals, dams, power plants and the like.

On the assumption that it would cost $2–$3 billion to provide expedient protection for the most easily defended types of industrial machinery, it did not seem unreasonable to estimate that providing equal protection (against 200 to 300 psi blast overpressure) for other facilities would cost up to ten times as much and would still leave a number of critical facilities in the economic infrastructure totally undefended. In reality, however, the committee could see no effective means of protecting such facilities as oil refineries short of reconstructing a significant portion of them deep underground, where they would remain vulnerable to having their supplies of crude cut off.

The committee's analysis of the diseconomies of industrial defense led it to conclude that firms would have little, if any, incentive to develop such capabilities voluntarily. Measures would be costly in terms of planning time, storage space for protective equipment and materials, training time, and, perhaps, lost production time. Industrial defense plans could in peacetime reduce output and thus productivity. Because nuclear effects and the measures needed to protect against them go so far beyond peacetime industrial hazards and the associated protective measures, industrial defense would do little, if anything, to improve the normal safety or productivity of these plants in peacetime. Finally, managers might also be inclined to adopt the attitude that the risk of nuclear war is remote, that profits will not be possible anyway in the post-attack economy, that protective measures are ineffective or that gambling on not being a target is a worthwhile risk. Therefore, without an array of government incentives and sanctions, expectations that critical enterprises would adopt the necessary measures seem to be wholly unfounded. The direct and indirect costs of these incentives and sanctions must be added to the calculus of industrial defense.

Additionally, the committee noted that the very low costs projected for industrial equipment protection would be achievable only if there were adequate advance warning of an impending attack, since expedient techniques are effective (to the extent they are effective at all) only under this condition of adequate advance notice to permit implementation. Although it is held that a nuclear attack would follow only after a period of deepening crisis which would provide advance notice of attack, this overlooks the fact that the exact timing of an attack is still very flexible within the several month period that defines most international crises (Cuba, Berlin, Six-Day War). By way of illustration a determined adversary has at least three simple options for overcoming any of the recommended measures for civil or industrial defense as follows:

1. Launch a nuclear attack while the crisis is still escalating but prior to the victim's directive to execute civil and industrial defense measures;

2. Launch a nuclear attack immediately upon notice that the intended victim has directed implementation of civil and industrial defense measures, thus increasing the damage; and

3. De-escalate the crisis, appear to give ground, and launch the nuclear attack as soon as the intended victim showed signs of relaxing any alert measures.

While it may be argued that this would not permit the attacker to implement his own protective measures, holding the initiative and controlling the element of surprise still permits the attacker to take actions on his own behalf. For example, the determined or desperate attacker could mask certain preparations (sending children and youth out of urban areas for summer camp) and carry out others in relative secrecy (commencing industrial protection measures at night), so that, upon launching the initial attack, he would have both a head start and the advantage of the "fog of battle" that would exist for at least several hours after the attack hit.[21]

One of the most troublesome problems in attaining an industrial defense effective against strategic nuclear attack is that it requires, as has been noted, a near total protection of all major industrial and economic assets, if some Achilles heel is not to be left that will provide a tempting target for adversary weapons and thus cause great injury to the economic system.

If, on the other hand, any future nuclear conflict remains "limited" (in that only a few military or industrial targets are struck), as some strategic analysts have suggested, the costs of protecting the entire industrial system will greatly exceed the costs of losing only a limited number of industrial facilities.

Again, setting aside reservations about the technical effectiveness of industrial defenses, to be militarily effective such defenses must be fully comprehensive in their application, leaving out no significant facilities. If such an industrial defense system could be achieved, it would only be cost-effective against massive attacks. Hardening the entire industrial system in order to withstand an attack on a small number of industrial facilities is much the same as paying a $1,000 premium to insure a one dollar object—it is a poor use of resources.

Considerations of this kind suggested that the primacy of the offense in the nuclear age may be as valid with regard to certain passive defenses as it is for active defenses. The primacy of the offense expresses the strategic axiom that it is less costly to overwhelm a defensive system with improvements or increases in offensive weapons than it is to buy the defensive system. It is this fact of life in the missile age which caused the United States and the Soviet Union to agree to ban all but two anti-ballistic missile systems; they were simply too easy to overwhelm at relatively low cost.[22]

In calculating the cost-effectiveness of industrial defense as a means of avoiding unacceptable damage, the same principle operates, since the very expensive measures required to protect certain types of fa-

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[21] "Fog of battle" describes the conditions of uncertainty and lack of information that exist at the outset of any major military enterprise, such as a landing or an attack.

[22] If, on the other hand, the issue is population protection and the objective is to save lives, then the cost-effectiveness calculations have a different aspect, for certain low-cost measures, such as marking and stocking fallout shelters, may be less costly than the expense of deploying forces adequate to overcome them.

cilities adequately can be countered by increasing the number of warheads used against them or by changes in the timing or configuration of the attack. The Boeing cost estimates thus failed to account fully for the costs of industrial defense and, even at these very low levels, did not purchase protection that could not be readily and cheaply overcome by a determined or desperate attacker.

Policymakers and planners will therefore want to examine closely whether the margin of overall economic protection gained by industrial defense, even elaborate and heavy defenses, is worth the high cost, when the remoteness of the risk and the ease of countering these measures are considered.

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Until more feasible methods and realistic costs could be developed for protecting a substantial portion of the economic infrastructure (requiring a series of unforeseen technological breakthroughs which the committee did not think likely), the committee was compelled to conclude that an effective and meaningful industrial defense adequate to mitigate the worst consequences of thermonuclear war lies beyond the grasp and the resources of even the superpowers. Furthermore, the committee believed that it would be dangerous to foster the impression in the nuclear age, whatever the motivation, that such defenses were possible, since it might give rise to miscalculations and superimpose on the offensive nuclear arms rivalry an even more costly industrial defense competition.

In preparing for war, care must be taken to avoid self-fulfilling prophecies. It is pertinent here to remark that studies in the last decade have shown that World War I was neither wanted nor expected by the participants. Yet, once mobilization was undertaken (largely as a means of communicating national resolve and purpose) it gathered a momentum that was beyond the control of political and military leaders. Thus, the great powers of Europe lurched toward a four-year, continental conflagration that none had sought but which all expected would be over in a matter of weeks or months, if it came. They became the victims of their own war preparedness.

Some of the measures currently being recommended for nuclear war preparedness are especially susceptible to this "lock-step" process. Urban evacuation and activation of industrial protection programs, whether ordered as part of a diplomatic bluff or in expectation that an attack might come from an adversary, could well precipitate the nuclear exchange that no nation wants, if the signals are misread or one party miscalculates, as occured in 1914.

IV. SOVIET INDUSTRIAL DEFENSE: SCOPE, EFFECTIVENESS AND MEANING

Analysis of passive defense and of recommendations for a U.S. passive defense program led to the conclusion that: (1) Program effectiveness would be marginal, even under ideal conditions; (2) passive defense measures could be easily overcome by an attacker, further degrading program effectiveness; (3) costs would be high even for this marginal program; and (4) undertaking such a program would involve an extensive planning and administrative effort. The committee then reviewed Soviet programs in this area to determine whether these same conclusions would apply.

Despite obvious and fundamental differences between the United States and the Soviet Union in strategic location, military posture, and economic system, the same general observations were confirmed. The structure of a modern industrial economy, whether capitalist or communist or mixed, contains certain notable and unavoidable vulnerabilities. In certain respects, Soviet industry has advantages over that in the United States as regards recovery from a nuclear attack. In other areas, the Soviet system is more vulnerable than that of the United States. For example, the Soviet economy develops larger inventories which would be of use during the economic reconstitution period before industrial recovery efforts could be mounted.[1] On the other hand, the Soviet economy under-produces vital spare parts for its transportation equipment and other machinery. It lacks the dispersed redundancy that is found in American industry. This redundancy results from the fact that in the United States a far larger percentage of productive capacity is devoted to producing non-essential consumer goods. Following a nuclear attack, some of this surviving consumer goods productive capacity would doubtless be switched to production of essential articles.

Though no evidence could be found to suggest that Soviet machinery and plant protection programs would overcome inherent vulnerabilities or that even these programs could withstand a well-planned attack, Soviet programs revealed two significant contrasts with the United States: (1) A far greater Soviet willingness to invest in programs that would have only very marginal utility against currently available nuclear weapons; and (2) an advantage in terms of the planning and administration required to mount a national industrial protection effort. The latter finding results, of course, from the nature of the Soviet economic and political system, which centrally controls Soviet industry. The former finding is analyzed separately in this

[1] Conventionally, the post-attack period is divided into relief, reconstitution, and recovery phases.

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section, while the latter is taken up in the course of analyzing specific Soviet programs.

The committee's review of Soviet programs confirmed that Soviet passive defense programs continue to be of greater breadth and depth than any parallel efforts ever mounted by the United States. This finding was qualified, however, by the recognition of several other factors. First, the Soviet Union has historically devoted far more of its security resources to defense rather than offense. Secondly, Soviet civil and industrial defense programs have been a consistent feature of their security effort since well before the advent of the age of nuclear missiles and owe much to the particular strategic setting and historical experience of the U.S.S.R. Finally, the current contrast between Soviet and American programs results as much from conscious and deliberate decisions of the U.S. government about the effectiveness of such programs as it does from the pace of Soviet efforts in this area.

Also of considerable significance is the fact that a major portion of the Soviet civil and industrial defense effort is aimed at clean-up and relief operations. This appears to reflect a belief that nuclear attacks will cause heavy damage, not that this damage can somehow be avoided or prevented.

Of special interest to the committee, therefore, was whether there was anything new in Soviet programs that would require the United States to revise its earlier estimates of the effectiveness of passive defenses. An evaluation of the Soviet economy, of specific elements of that economy, and of the role of passive defense programs in protecting the material infrastructure of that economy was therefore made with the question of feasibility of achieving effective passive defense as the primary interest.

Vulnerability of the Soviet Economy

A prerequisite of avoiding unacceptable economic disarray or collapse (and possibly political upheaval or breakdown) following a nuclear attack is a robust agricultural and industrial base prior to the attack. Recovery obviously cannot offset deficiencies existing in the economic system at the time of the attack. In fact, the possibility and the rate of economic recovery is heavily determined by the state of the pre-attack economic system. A robust pre-attack economic base would include: Efficient use of investment and other factors of production; an adequate mechanism for allocating these and other resources; effective and resourceful management; a healthy and highly articulated transportation system; a well-developed power generation and distribution system; rapid, effective and redundant networks for the collection, analysis and dissemination of data and other information; a skilled, motivated, and flexible labor force; and an overall industrial and agricultural production system (plant and equipment) capable of rapid adaptation and ready absorption of technological innovation.

A review of the current literature on the Soviet economy revealed a number of deficiencies that portend serious problems for post-nuclear-attack recovery. The performance of the Soviet economy during the ninth Five Year Plan (1971–1975) was less than anticipated, with the actual growth rate of 3.8 percent running well behind the planned goal of 5.8 percent. It disclosed special problems that bear directly

on recovery capability. Among these problems were weak agricultural performance (requiring large grain imports), large and chronic balance of payments deficits (which reflect increasing Soviet dependence on the importation of Western technology), and a very large number of uncompleted major construction projects which will retard growth in the future. As a result, the tenth Five Year Plan contains goals which are the most modest in the history of the Soviet Union.

Exemplifying Soviet industrial production problems is the fact that consumer demand consistently outstrips production by wide margins. This does not mean demand for luxury goods but for the essential requirements of the Soviet populace, which continues to experience chronic shortages of basic goods. All Western analysis of the Soviet economy is in agreement that it is unable to solve the problem of providing essential consumer goods even in peacetime. The weaknesses in the Soviet economy are illustrated by the contrasts between the goals of the ninth and tenth Five Year Plans. The former, for example, established a growth rate of 6.4 percent for new fixed capital investment. The latest plan seeks only a rate of 3.5 percent. The trouble-plagued agricultural sector will continue to receive special attention, absorbing one-quarter of total investment.

Even areas of apparent Soviet strength reveal vulnerabilities when examined in terms of post-attack recovery capabilities. While the Soviet Union is the largest producer of crude oil in the world, its ability to expand production of all energy resources in order to meet growth goals is heavily dependent on the importation of technology from American firms, with which it has signed a number of long-term agreements.

FOSSIL FUEL PRODUCTION, U.S.S.R.—UNITED STATES, 1975[1]

	Crude oil output (millions of metric tons)	Natural gas output (billions of cubic meters)	Coal output (millions of metric tons)
U.S.S.R.	491.6	289.3	701.1
United States	407.2	569.1	584.8

[1] Nevertheless, primary energy production (in million metric tons of coa lequivalent) was far higher (2,165) in the United States than in the U.S.S.R. (1,643) in 1975.

The often touted figures on Soviet steel production, to the extent that they can be accepted as accurate, reflect not only the very heavy concentration of investment in this basic industry since World War II but also the inability of the centrally planned Soviet system to absorb new technologies, in this case the lower cost synthetic substitutes for steel, such as plastics, which are abundantly used in the United States, thus reducing the requirements for steel output.

The comparative efficiency of American production is reflected in the ability of the U.S. economy to generate a Gross National Product of $1,516.3 billion (or $7,098 per person) as opposed to the Soviet Gross National Product of $865.3 billion (or $3,400 per person) in the same period.[2] A GNP of about half that of the United States is generated by a larger population (254.5 million vs. 213.6 million) wherein all

[2] Thus, Soviet defense expenditures of 13 percent of GNP (as estimated by the CIA) are quite comparable to U.S. defense expenditures of 6 percent of a GNP that is twice as large.

employable individuals are nominally employed but in which many are in fact under-employed or inefficiently utilized because of deficient production methods and lack of motivation even in the face of centrally established production quotas.

These quotas are often met by juggling statistics and other subterfuges (such as avoiding methods or tasks which do not produce high figures) and are treated with considerable skepticism by Western analysts, as are performance figures. Certain types of production, such as spare parts for equipment, are not as well rewarded under the Soviet system as others, which leads to shortfalls in industries dependent on the output of more basic industries.

Likewise, Soviet production techniques are far less efficient than American counterparts. American industry, for example, uses 95 percent of the metals it consumes in the final product, wasting only 5 percent in the manufacturing process. In Soviet industry, 75 percent is used and 25 percent is wasted. On the average, Soviet machinery is 25 percent to 30 percent heavier than American industrial production equipment, requiring not only larger inputs of steel and other materials but also larger inputs of energy to operate it. Gross figures for steel and energy production are more a reflection of the inefficiency of Soviet manufacturing than they are a sign of a strong and growing economy.

Most Western analysts agree that the central planning mechanism of the Soviet economy bears a significant responsibility for the generally weak performance of that economy, in which shortages and shortfalls are endemic. At the same time, however, it provides an administrative mechanism for carrying out the pre-attack preparedness measures that lie at the heart of a national industrial protection scheme. Here, the central planning mechanism, with its ability to allocate capital resources, establish uniform standards, direct preparedness priorities and punish or reward performance, has advantages over the private industry of the United States. Whether such a centralized system, with its reliance on a rigidly hierarchical system of command and control, would respond with the necessary flexibility and function well if the central control apparatus were disrupted remains questionable. There is reason to believe that the value system which central planning encourages would act to rob regional and local and sectoral managers of the initiative and resourcefulness necessary in a post-attack recovery environment. More importantly, perhaps, given the existing coordination problems in Soviet industry and the very grave weaknesses in the Soviet ability to collect accurate data, process and analyze it, and respond to its implications, there is even more reason to doubt the capacity of central planners to coordinate the damaged industrial system in the post-attack period. The inability of Soviet planners to coordinate effectively within and between sectors of industry in peacetime raises questions about the probable performance of this centrally managed (and therefore centrally dependent) system after nuclear attack.

A noteworthy example of the wastefulness and inefficiency possible in a centrally managed economy is the unofficial Soviet practice of "storming" or concentrating production at the end of the month in order to meet monthly quotas or goals. Because this practice is found throughout Soviet industry, it affects even plants where managers attempt to maintain a consistent level of productivity but are pre-

vented from doing so because supplies and components required for their operation do not reach them until well into each month as a result of "storming" on the part of suppliers. Nobel Prize-winning Soviet economist Leonid Kantorovich has suggested that supplanting this "storming" phenomenon with more rational use of resources would increase national income by one-third to one-half.[3]

The significance of this and related production phenomena is that the planning mechanism artificially induces bottlenecks or production humps in the industrial system even under normal conditions. Whether this same mechanism can eliminate even larger bottlenecks and unevenness in productivity following a nuclear attack remains very much to be seen. Even if the basic production capacity remains largely intact after a nuclear exchange, it appears that avoidance of more severely debilitating bottlenecks and production gaps will be difficult to achieve.

It has been noted that the large supply of labor in the Soviet Union provides at least a presumptive edge over the United States in terms of post-attack recovery. The Soviet labor force totals 136.1 million workers, to the U.S. 94.8 million. Realization of such an advantage, however, depends greatly on whether the Soviet industrial administration can efficiently utilize the labor available. Based on the experience of the peacetime economy, there is little warrant for the assumption of effective use of labor under post-attack conditions. Though the psychological stimulus of fighting again for Mother Russia may prove a certain boon, it could well be off-set by the immediate demoralization which the Japanese experience and most social scientists indicate will follow the sudden and large-scale destruction of a nuclear attack.[4] At the very least, it is hard to imagine that the benign effects of nuclear destruction on individuals and social institutions would act to overcome the serious problems with the productivity of Soviet labor.

Labor productivity in the U.S.S.R. has been roughly one-third of that in the United States (where productivity remains higher than in all other countries of the world). This disproportion has changed relatively little over the 15 year period from 1960 to 1974. Because of falling worker productivity, the U.S.S.R. faces a labor shortage. The weakness of labor productivity results in part from lack of investment in labor-saving equipment. But this is not the only cause. As Leonid Brezhnev described the problem at the October 1976 Central Committee Plenum:

> . . . we still have many, too many, cases of absenteeism, latecomings and forced idleness. This is a great evil entailing the loss of millions of man-days. And all Party organizations, all the public should be roused to fight it.

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[3] Unless otherwise noted, data in this and following sections relating to the Soviet economy has been provided by the Congressional Research Service, Library of Congress, or has been drawn from the following sources: "Soviet Economy in a New Perspective," a compendium of papers submitted to the Joint Economic Committee (Washington: Government Printing Office, October, 1976); "Russia: The People and the Power," Robert G. Kaiser (New York: Atheneum, 1976); U.S. News and World Report; The New York Times; and "Allocation of Resources in the Soviet Union and China 1976," Hearings before the Subcommittee on Priorities and Economy in Government, Joint Economic Committee, May 24, and June 15, 1976.

[4] For the actual and possible effects of nuclear attacks on individuals and institutions, see: "The Atomic Bombing of Hiroshima and Nagasaki," Report of the Manhattan Engineer District, mimeo, n.d.; S.D. Vestermark, Jr., ed., "Vulnerabilities of Social Structure: Studies of the Social Dimensions of Nuclear Attack," Human Sciences Research Inc. for the Office of Civil Defense, Department of the Army, December, 1966; Fred C. Ikle, "The Social Impact of Bomb Destruction," op. cit.; and Robert Lifton, "Death in Life."

Early drafts of the tenth Five Year Plan called for a 30 percent to 34 percent growth in productivity over the period 1976 to 1980. This target was subsequently lowered to 27 percent, then to 25 percent in the final plan, and early in 1977 the Soviet government announced shortfalls in productivity growth goals for 1976 in several crucial economic sectors, especially industry, construction and the railroads. Twenty percent of the industrial enterprises in the Khabarovsk region, for example, failed to meet their planned quotas. Meanwhile, Pravda has noted that one-half of new industrial initiatives planned for capacity production during 1975 had failed to achieve full production. The explanation given was that managers intentionally set low output targets in order to be sure of exceeding them easily.[5] Among the various factors cited by Soviet and Western analysts alike for low productivity and high absenteeism is heavy drinking.

Among the measures currently being stressed by Soviet planners for overcoming low productivity are labor specialization, automation, and mechanization, all of which tend to reduce flexibility for post-attack recovery and to make the industrial base more vulnerable to nuclear attack damage by supplanting simple tools with sophisticated ones which are more difficult to protect and replace.

Overall productivity, however, does not rest on labor productivity alone. It expresses the relationship between quantities of goods and services produced and quantities of inputs—labor, capital, and materials, required to produce them. The strong and direct correlation between productivity performance and technological capacity has long been known to economists. Hence, technological progress is one of the important contributors to productivity increases. The productivity of labor and capital are especially useful indicators, since these factors tend to be the primary "carriers" of technology in the production process. The consistently high productivity levels found in the United States reflect higher labor productivity, better allocation of capital resources, and greater technological acumen or capacity to absorb new technology.

At the same time, any advantage to be derived from a larger labor force is limited by the fact that many of the fundamental elements of a modern industrial economy, such as petroleum refining and electric power generation, are capital intensive industries where labor cannot be substituted by physical plants. Nor can the employment of labor-intensive techniques in manufacturing facilities themselves appreciably or readily offset the disruption in the supply of vital fuels and electric power than could be achieved in an industry-oriented nuclear attack.

Chronic problems in developing and integrating new technology into the Soviet industrial production scheme have led the Soviet planners increasingly to shop abroad for Western technology. They have signed agreements for a variety of sophisticated products with American and other Western firms and have even bought entire factories, such as the Togliatti automobile works built by Fiat, from Western suppliers in order to overcome these technological deficiencies. An area often singled out as exemplary of Soviet technological difficulties is computer technology, where the Soviet Union lags well behind Western nations.

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[5] Christopher S. Wren, The New York Times, Jan. 30, 1977.

The implications of this situation are two-fold. First, because the ruble is not a hard currency for overseas trade, the Soviets have had to incur a hard currency deficit now estimated at $20 billion to pay for the importation of technology. This, even more than grain imports, has caused repeated and severe balance of trade deficits, which are now a major recurring problem for the Soviet economy, since overseas markets where Soviet products can generate hard currency are few. The increasing dependence of the Soviet Union on foreign trade to offset weaknesses in technology development and agriculture, as well as other fields, reflects the decisive secular trend away from the original communist goal of autarky, or economic self-sufficiency, and hence an increased vulnerability to economic disruption through loss of foreign trade possibilities following a nuclear attack. In addition, East European economies are being called on to subsidize Soviet economic problems, leading to the kind of troubles that affected Poland during 1976.

Secondly, the notable difficulties of Soviet industry in developing and absorbing new technology (despite the well-known excellence of Soviet science, especially in such fields as mathematics and physics), reflect the tendency of the planned economy to build in strong disincentives to innovation, ingenuity, and resourcefulness. This not only hampers the development of a strong pre-attack industrial base, it suggests an additional source of problems during any post-attack recovery phase when improvisation and resourcefulness will be at a premium.

Taken together, these basic problems in the Soviet economy suggest the implausibility of contentions that Soviet post-attack recovery could be completed in as little as two to four years. The further contention that, even if 100 percent of Soviet industrial capital value were destroyed and 50 percent of the labor force was killed in a nuclear attack, the Soviet Union might nevertheless require only 16 years to attain its pre-attack level of Gross National Product appeared impossible on the face of it.[6] To achieve this would mean that half the current Soviet labor force without any surviving machines and equipment could produce in 16 years what the full labor force is capable of producing today with all its capital equipment intact. In other words, after a nuclear attack, the U.S.S.R. could double its GNP per capita in a mere 16 years.

Far more importantly, it appears from aggregate statistics that a carefully configured nuclear attack on the Soviet Union would so aggravate existing weaknesses in the economic infrastructure that efforts to continue prosecuting any kind of a war beyond a territorial defense would be extremely difficult, if not impossible.

Aggregate statistics are useful, however, largely for the purpose of establishing the general lack of robustness of the Soviet economy and its chronic difficulties in meeting the peacetime needs of Soviet society. A more specific understanding of the vulnerabilities of the Soviet economy is required for the purpose of assessing the feasibility and effectiveness of industrial defense. Two methods which have been used to analyze the vulnerabilities of American industry are (1) identification of areas of industrial concentration through evaluation of the

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[6] See figure 1, page 4, Appendix 2, of "The Defense Industrial Base: Industrial Preparedness and Nuclear War Survival," hearings before the Joint Committee on Defense Production, Nov. 17, 1976.

manufacturing-value-added (MVA) in U.S. standard metropolitan statistical areas (SMSAs) and (2) identification of specific types of industry that are critical to industry as a whole through evaluation of input-output (I/O) tables.[7]

From the first method it is possible to isolate industrial areas which, if severely damaged by nuclear attack, would have the most serious repercussions for the economy as a whole. Use of the second method permits identification of those specific industries (and therefore specific plants) which, if targeted and destroyed, would cause the gravest reverberations in the economy generally. Users of the second method contend that it also gives a more accurate tool for damage assessment since ". . . relatively low levels of MVA destruction can lead to significant reductions in the ability to support a war effort." [8]

In the absence of manufacturing-value-added data by locality on the Soviet Union, the use of the second method is dictated. Its application to an input-output model for Soviet industry has revealed that damage to the following types of industry would cause the greatest problems for continued prosecution of a war effort: nonferrous ores, transportation machinery and equipment, machine tools, forging and pressing machinery and equipment, pumps and compressors, and precision instruments.[9] Bottlenecks could be achieved, according to this study, at levels of destruction as low as ten percent in 71 separate sectors of Soviet industry. Though the study did not provide data on the number of weapons required to achieve this effect in the Soviet Union, damage adequate to induce serious bottleneck effects in the United States could be created by attacks of 100 to 300 nuclear weapons. Because of the far higher concentration of basic industries, such as steel, in enormous plants in the Soviet Union, it is reasonable to assume that equally serious production disruptions can be achieved with equivalent numbers of weapons. Though many of the Soviet industries identified as economically critical (in terms of their crucial position at the base of production pyramids) involve heavy, blast-resistant equipment and are subject to hardening by expedient or permanent methods, none of these industries are invulnerable to MIRV warheads.

Aside from industry directly related to war production, there are a number of sectors of the Soviet economy which are even more vulnerable to nuclear weapons and which play a central role in the post-attack viability of the economy and, indeed, of Soviet society. Without surviving food production capacity and a healthy transportation system, for example, the survival of individual war-related factories becomes nearly irrelevant to post-attack recovery, since these units and Soviet military forces will require both adequate food supplies (for troops and the labor force) and effective means of transportation to remain operational. While caloric intake can be reduced somewhat to offset losses in agricultural production, the demands on transportation assets will be even heavier than in peacetime as a result of evacuation plans, relief operations, industrial mobilization, and military

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[7] See the following studies cited earlier: "Potential Vulnerabilities Affecting National Survival" and "Data Base and Damage Criteria for Measurement of Arms Limitation Effects on War-supporting Industry."

[8] "Data Base and Damage Criteria . . ." op. cit., p. 44.

[9] *Ibid.*, p. 52.

operations. These two facets of the Soviet economic system were therefore given special attention in the vulnerability analysis of Soviet production.

Vulnerability of Soviet agriculture

Despite the existence of large but destructible grain storage facilities and programs aimed at retaining fresh foodstuffs (five days to two weeks supply) in shelters, the problem of feeding the Soviet population over an extended period appears very large when viewed in the context of Soviet agricultural experience.[10] The persistent inability of the Soviet government to feed its own people adequately in peacetime without repeated importation of grain or other foodstuffs—the result of under-investment in agriculture during the"heavy industry" five year plans of the 1940s and 1950s—suggests that agriculture represents a major vulnerability in the Soviet economy and therefore a major disincentive to engaging in a nuclear war that would decimate this already fragile base.

While it is true that the adult population (excluding the aged, infirm or very young) could survive on reduced caloric intake for significant periods, it remains questionable how long the adult population could or would care to sustain industrial production, relief operations, and a continuing war, if there were chronic shortages of food and no prospect of relief through overseas import of foodstuffs. In this regard, the experience of World War II appears to hold few parallels, for in a nuclear war the Soviet Union would lack the vast and undamaged hinterland east of the Urals that it relied on then. Nor would it have the food convoys provided by the United States. Moreover, the extreme rapidity of nuclear attack destruction, even attacks lasting several weeks, would not permit the time-consuming relocations and adjustments which Soviet agriculture and industry were able to make in the face of the German invasion.

Over the last 15 years, Soviet agricultural imports have accounted for more than one-fifth of total Soviet imports. Between 1961 and 1965 and again between 1971 and 1975, imports of agricultural products constituted 23 percent of imports and they comprised 22 percent of the whole during the period 1966 to 1970. In contrast, Soviet agricultural exports have steadily declined, averaging 17 percent of total exports between 1961 and 1965, 14 percent of total exports between 1966 and 1970, and 9 percent of total exports between 1971 and 1975, hitting a record low of 7 percent in the last year. Of even greater significance is the fact that, whereas the value of Soviet agricultural imports had never gone beyond $2.5 prior to 1972, the value rose to $5 billion in 1973 and almost doubled to $10 billion in 1975. With agricultural exports at about two billion dollars in 1975, this meant a net trade deficit or import dependency of around $7 billion

[10] The Soviet hardened grain storage facilities are cited by Maj. Gen. George S. Keegan, Jr., USAF (Ret.), former chief of Air Force intelligence, in the New York Times, Jan. 4, 1977. See also the enclosure to the letter of Gen. George S. Brown, Chairman of the Joint Chiefs of Staff, to Sen. William Proxmire, dated January 28, 1977. It appears that the capacity of these grain bunkers represents a very small fraction of annual Soviet requirements.

for agricultural products.[11] Soviet grain production per acre runs between 50 and 60 percent of U.S. yields.

In its Five-Year Plan for the first half of this decade, the Soviet Union sought to fulfill increased demand for livestock products from its own production. Since feed was unavailable for this purpose, the Soviet leaders resorted to grain imports to offset the shortage. Exacerbated by the drought of 1975, this shortage outran even imports and, as a result, many livestock had to be slaughtered.

This experience led the Soviet leaders in October, 1975 to sign an agreement with the United States providing for the Soviet purchase of from six to eight million tons of wheat and corn annually for the period 1976 through 1980. This agreement corresponds to the average annual Soviet grain purchases from the U.S. of eight million tons per year over the preceding five years.

Efforts to improve the condition of Soviet agriculture in the tenth Five Year Plan must cope with a number of obstacles. Productivity per unit of labor in the agricultural sector is even worse than in industry. Soviet agriculture employs 25 percent of the Soviet labor force, as opposed to 4 percent in the United States, to produce far less than American agriculture does. Mechanization, long a by-word of the agricultural portions of the Soviet plans, has not led to dramatic improvements. According to Soviet publications, grain combines were idle two-thirds of the time they might have been in use during 1976. In the tenth Five Year Plan, the Soviets will again try to upgrade their tractors to world standards, a goal that was not met in the ninth Five Year Plan. Even if achieved, Soviet farm equipment will still not compare with that in the U.S. where analysts report that pressure for improvements in tractor performance is even stronger than in the U.S.S.R. And the U.S. base is far larger: the U.S.S.R., for example, has only 5 percent as many trucks per 1000 farm workers as the U.S.

Upgrading the quality of Soviet tractors involves, among other things, increasing horsepower, yet American experts predict that the new, higher horsepower models will be under-utilized because of the lack of the auxiliary machinery required to make them productive. Even current tractors are under-utilized, albeit for different reasons; during 1976, four out of five tractors had to be taken out of operation because of the lack of spare parts or shortage of trained mechanics that hampers all sectors of the Soviet economy. The Soviet attempt to upgrade tractor performance may flounder on lack of experience; the Pavlodar tractor plant will attempt full-scale production of a 300-horsepower wheeled tractor, though its normal production item has been limited to a very different, 90-horsepower tracked unit.[12]

As in the past, the Soviet planners are expected to continue offsetting poor agricultural labor productivity and weak mechanization by diverting military units and school-age youths to help sow and harvest crops.

Beyond the continued reliance on imported American grain, Soviet plans for rebuilding decimated livestock herds and meat production and for coping generally with its chronically troubled agricultural

[11] David M. Schoonover, "Soviet Agricultural Trade and the Feed-Livestock Economy" in "Soviet Economy in a New Perspective," A Compendium of Papers Submitted to the Joint Economic Committee (Washington, D.C.: Government Printing Office, October 1976), pp. 813–819.

[12] The term tractors includes both the wheeled vehicles conventionally called tractors in the United States and tracked vehicles more commonly known in the United States as bulldozers.

system include increased use of fertilizers, increase in grain cultivation, and expansion of irrigation, including irrigation of grazing lands. Nevertheless, growth in terms of livestock production are modest and may not be adequate to meet increases in demand resulting from population growth and scheduled wage increases. Continued shortfalls in livestock production are expected to bring an increase in the importation of livestock products. Moreover, even modest improvement in this sector of the Soviet "economy of queues and shortages" is contingent on normal weather and, as experience has shown, "weather is rarely normal." [18]

Soviet agricultural problems suggest not only the primary reason for the increase noticed recently in large grain storage facilities but also a special and continuing vulnerability of the Soviet economic system, one which would have a direct bearing on Soviet ability to withstand and recover from a war of any kind, especially a nuclear war. The already heavy reliance on irrigation and the increasing reliance on fertilizers reveals yet another set of unprotectable targets in the form of hydraulic systems and petrochemical and fertilizer production plants, in addition to grain storage facilities.

Three million square miles of Soviet territory requires irrigation to be productive, while another million square miles requires drainage. Hence, to cripple the Soviet economy and hinder its recovery with relatively little industrial damage and few population fatalities, a nuclear attack could be configured to target major dams, pumping stations, locks and other physical features of the large Soviet hydraulic system, thereby reducing significantly the already inadequate amount of cultivable territory in the U.S.S.R., without even considering the short- or long-term effects of radioactive fallout on food production. An additional component of such an attack could be Soviet industrial facilities committed to production of agricultural equipment and critical spare parts, such as the tractor factories at Chelyabinsk and Pavlodar. Only nine factories produce over 80 percent of Soviet tractors annually. The loss of large stretches of cultivable land and the mechanized capability required to farm it would create a problem for the Soviet leadership of insoluble dimensions, in terms not only of prosecuting a war but of ensuring the survival of the regime without massive external assistance.

Moreover, because of the interconnection between the Soviet irrigation-drainage system, hydroelectric power system, and inland waterway system (Volga-White Sea Waterway, Don and Dnepr Waterways), an attack aimed at dams, locks, and power generation stations would severely hamper industrial production generally and vital transportation assets specifically, by preventing the use of navigable waterways and removing some of the electrical generation capacity required to operate the electrified portions of the Soviet railway system.

Vulnerability of Soviet transportation

Many of the problems that plague mechanization in Soviet agriculture—poor equipment, lack of adequate spare parts, a paucity of trained mechanics—are to be found in Soviet transportation systems.

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[18] Ibid., pp. 815, 817, 818, and 819.

Yet the problems which impact most seriously on post-attack recovery are of even greater magnitude. The system of roads in the U.S.S.R. continues to be highly inferior both as to road surfaces and extent of the highway network. Although twice as large as the United States, the Soviet Union has only 250,000 miles of paved roads to 1,855,360 miles of surfaced roadways in the United States. In addition, the U.S. has 1,245,344 miles of gravel roads and 737,442 miles of dirt roads, providing the most highly articulated network of roadways in the world. The redundancy in the American highway system (combined with the very large fleet of trucks, buses and other conveyances) alone provides a significant asset for aiding in post-attack recovery.

By contrast, the Soviet highway system, including even paved roads, is in generally poor condition and boasts nothing like the Interstate Highway system. Urban roadways in the Soviet Union carry twice as much traffic as they were designed to handle. The Moscow-Orel highway carries 20,000 vehicles per day, is full of potholes and poorly marked. The Moscow-Leningrad highway, even after a major rehabilitation, lacks adequate automobile service and repair stations. There is no continuously paved road from the western border of the Soviet Union to the eastern.

Into an inadequate road system and an inadequate spare parts and repair service system, the Soviet planners are nevertheless sending an increasingly large fleet of automobiles, as the Volzhsky auto plant, containing Western machinery bought on credit, adds its production of Zhigulis to existing Soviet car production. This will place severe strains on a transportation system which Soviet officials themselves concede is already "deteriorating."

Production of automobiles in the Soviet Union, of course lags well behind that in the United States.

AUTOMOBILE PRODUCTION, UNITED STATES-U.S.S.R.

	1975	1976
U.S.S.R.	1,201,000	[1] 1,250,000
United States	6,713,000	8,497,000

[1] Estimate. Data for 1975 from the Office of Economic Research, Central Intelligence Agency and for 1976 from U.S. NEWS AND WORLD REPORT.

Today, there are over 106,712,551 registered private, commercial and publicly-owned autos in America together with 25,775,715 registered trucks and over 462,144 registered buses (December 1975 data). In the Soviet Union, on the other hand, private car ownership now amounts to some four million autos. More significant from the standpoint of industrial mobilization or post-attack recovery is truck and bus production capacity. During 1975, the United States outstripped the Soviet Union by 2,272,200 units to 763,000 units.

Construction of new Soviet roads, even dirt roads, and railway roadbeds is hampered by the same problem that holds back Soviet agriculture—poorly designed and underpowered tractors and bulldozers.[14] Soviet emphasis on output has led to the production of thousands of

[14] Completion of the new Baikal-Amur railway line to promote the economic development of Siberia under the tenth Five Year Plan is expected to depend heavily on improvements in the area of construction equipment.

standardized units which make no concessions to the type of work for which they will eventually be used. Despite the fact that nearly 28 percent of Soviet tractor and bulldozer output each year is assigned to industrial use, the bulk of these units are designed primarily for agricultural use. Reportedly, one-fourth of the tractors and bulldozers used in industry, such as construction, are designed for the purpose for which they are used. Some 19,000 of the 20,000 tractors produced in 1974 for special applications were designed only for logging operations. The basic bulldozer used in Soviet road construction is a general-purpose agricultural vehicle. No distinction is made in the design of this equipment to allow for use in different conditions and climates; hence, the same vehicles employed in the northern regions of permafrost and snow are used in the southern desert areas.

Likewise, other road construction equipment continues to be outdated or ill-adapted to the purpose. A 1976 article in Pravda, for example, pointed out that the vibratory compacting machines (so commonly seen in the U.S. on road projects) tamp down rock and gravel more effectively than static rollers. Nevertheless, the article notes, Soviet industry concentrates on making the static rollers because they are simpler to produce and, being heavier, make it easier for factories to meet tonnage targets.

Nevertheless, Soviet tractor production is, as the plan requires, very high, exceeding U.S. production of tractors and other vehicles in the same class by 200,000 units in 1975. Soviet production, on the other hand, is subject to very high retirement rates as a result of poor construction and poor maintenance. Here again is another uneconomical end-use of steel that accounts for the very high quantities of steel produced in the Soviet Union annually. The spare parts problem that infects Soviet industry generally also degrades the performance of the transportation system, both as regards construction equipment and trucks used for transporting goods. It has been estimated that, at any given time, one-third of Soviet trucks are idled for lack of spare parts or trained mechanics. Much the same is true of railway rolling stock, where repair facilities tend to concentrate on the more easily repaired types of rolling stock, so as to be able to fulfill monthly work quotas.

Much of the Soviet railway system is also electrified, making power generation stations doubly important to industry, since loss of electricity will affect industrial production both directly and indirectly through failures in the transportaion system. To a far greater degree than in the United States, the Soviet Union relies on a system of inland waterways to augment rail and road transportation. Since World War II, great efforts have been made to widen and deepen natural channels and to build locks or other means of bypassing natural barriers, in order to extend the capabilities of this system. Now it is possible to move naval vessels as large as destroyers between the Black Sea and northern ports via this inland water route. Damage to the canals and locks or simple bottlenecking of the newly dredged channels that make up these important arteries, such as the Volga-White Sea Waterway, would throw a heavy additional burden on the already overtaxed rail and road network.

Although Soviet civil defense manuals call for the dispersal of transportation resources upon warning of an impending nuclear at-

tack, the actual trucks, rolling stock, barges, engines, and other vehicles or vessels that make up these resources do not, in any case, present worthwhile aim-points for nuclear weapons. Far more damaging to the Soviet economy, and hence to its political future or any war effort, would be the loss of a number of intrinsically vulnerable and critical elements of the transportation system the survival of which is critical to post-attack recovery. Among these elements are: tractor and other construction equipment plants; rail heads and marshalling yards; major truck and rolling stock manufacturing and repair facilities or spare parts factories (such as automotive battery factories); hydroelectric facilities supporting electrified rail lines; sea and river ports; major surface transshipment points and highway intersections; bridges and tunnels; major port facilities and shipyards; locks, dredged channels or other features of the inland waterway system; airports; fuel refining and storage facilities; and cargo aircraft assembly plants. Heavy damage can be inflicted on most of all of these elements without targeting population centers *per se* or the more readily hardened components of Soviet industry. Yet heavy damage to these elements would paralyze the Soviet economy for months and probably years, setting back more than thirty years of painstaking and costly Soviet development.

Moreover, the well-known paucity of Soviet warm-water ports and access routes to the open sea provides other means of bottlenecking the Soviet supply and transportation system through the aerial mining of the few all-weather access routes. (Presumably, however, Soviet reliance on overseas imports of foodstuffs, materials and other goods would have to terminate at the onset of nuclear war for other reasons.) If damage to the transportation and supporting systems is combined with damage to the agricultural system, the problem of survival as a world power would be even more gravely complicated for the Soviet leadership.

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Even if Soviet industrial protection programs grow extensively in quality and scope, beyond what current levels of investment would indicate is possible, there will therefore remain large numbers of unprotectable but crucial targets, damage to which will seriously undermine and perhaps prevent for very long periods any meaningful economic recovery effort. Certainly this will be the case if, during the extended recovery period, the Soviet Union is forced to continue prosecuting an offensive or defensive war, or to maintain order within its own borders and the communist bloc generally, or to rely solely on its own resources to accomplish these goals as well as support recovery efforts. When the ability of MIRV warheads to penetrate even heavily hardened facilities is added to the equation and when the general lack of robustness and redundancy in the pre-attack economic system is taken into consideration, there appears to be little warrant for the belief that the Soviet Union could survive even a modest yet carefully configured nuclear attack in any but the most primitive economic circumstances. In short, vulnerability analysis of the Soviet economy discloses no practical means of reducing the number of critical targets to a level so low that it would have any effect on the basic premises of nuclear deterrence. In view of the ease with which even

highly effective industrial protection measures can be circumvented (due to their very limited applicability), the committee could see no reason to revise earlier U.S. estimates of the unfavorable cost-benefit ratio of industrial defense.

Soviet Passive Defense Programs

Background

The Soviet Union has maintained peacetime industrial and civil defense programs, like the United States, since the aftermath of World War II.[15] Also like the United States, it has tried several organizational structures for accommodating this mission. Originally, these programs were a part of the Ministry of Internal Affairs. During the late 1950's and early 1960's, when the missile "gap" scare focused attention in both the U.S. and U.S.S.R. on civil and industrial defense, significant changes were made in the civil and industrial defense mission organizations in both countries.

The watershed year in both cases was 1961. In that year passive defense programs in the Soviet Union were assigned to the Ministry of Defense under a Deputy Minister of Defense who served also as the operational Chief of Civil Defense. In the same year, President Kennedy instituted a sweeping overhaul of the U.S. civil and industrial preparedness effort when he assigned primary operational responsibility to a newly created Assistant Secretary of Defense for Civil Defense (ASD(CD)) and reorganized the White House emergency planning and coordination function in the new Office of Emergency Planning.

Some years later, in 1967, the Soviet Union established the Moscow Military School of Civil Defense, analogous to the Civil Defense Staff College established by the United States in 1951 at Olney, Md. and relocated to Battle Creek, Michigan in 1954. The American staff school is, however, only one of several civil defense training and education programs maintained by the U.S. government at participating colleges and universities and through correspondence courses.

Subsequent to the 1961 reorganization, the Deputy Minister of Defense in charge of civil defense, who had formerly also commanded Soviet Ground Troops, was given responsibility for industrial and civil defense programs alone. In consequence of this split in responsibilities, the Chief of Civil Defense post was thereafter assigned to a colonel-general, whereas previously it had been filled by a full marshal of the Soviet Union.[16]

The Soviet passive defense program contains all the elements of a comprehensive program—continuity of government, defense of mili-

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[15] Soviet civil defense against aerial attack predates World War II, as it does in most European countries.

[16] To the extent that incumbents of high-level positions are meaningful indices of policy direction, an event of more recent significance is the appointment of General Nikolai Ogarkov as chief of staff of the Soviet military forces. General Ogarkov, who had been deputy chief of staff and Soviet military representative to the SALT, is reported to be leading Soviet expert on strategic arms limitations.

Information on Soviet passive defense programs and those of other countries is drawn from the following sources: Leon Gouré, "War Survival in Soviet Strategy" Coral Gables, (Coral Gables, Florida: University of Miami, 1976); "Civil Defense, A Soviet View," translation of the Soviet publication "Grazhdanskaya Oborona" of 1970 by the Oak Ridge National Laboratory as revised and edited by the United States Air Force (Washington: Government Printing Office, 1976); Sidney D. Drell, Arthur A. Broyles and Eugene P. Wigner, "Civil Defense in Limited War—A Debate," Physics Today, April 1976.

tary assets, defense of the industrial base, including the labor force, and defense of the general populace. Continuity of government in the U.S.S.R. appears to be provided for in much the same way as in the United States, that is, through hardened leadership and governmental relocation sites outside the central and regional government centers similar to the American Federal Relocation Arc in the mountains near Washington and Alternate Relocation Sites near federal regional headquarters. (See pages 5–7.)

The permanent, full-time staff of the Soviet civil defense organization, a majority of whom are military, has been estimated to number as high as 72,000 persons throughout the country.[17] This estimate, however, assumes that all units existing on paper are manned at full, mobilization strength. Factual data confirming this manning level estimate is not publically available, however. Given the normal Soviet practice (followed to a lesser degree in the United States) of not manning noncombat units to full war-time strength during peacetime, estimates of full-time civil and industrial defense cadres based on tables of organization can be discounted by as much as 35 percent. In any case whether the full-time personnel committed to industrial and civil defense number 50,000 or 72,000, neither figure appears to represent a particularly significant passive defense capacity, nor are they greatly different from the number of personnel with civil defense training and responsibilities in the many private, voluntary organizations and local, state, and Federal Government organizations concerned with preparedness in the United States. Whether a larger full-time bureaucracy constitutes a meaningful edge in terms of program effectiveness remains the subject of some doubt.

No data exists in Western sources on the exact amount of Soviet spending on passive defense programs, though speculation has centered on an annual figure of one billion dollars.[18] Judged by estimates of what only partially effective programs would cost in the United States, this figure did not appear to be adequate to purchase more than a rudimentary capability for population protection and relief efforts, with very little left for allocation to economic reconstitution and recovery. If a substantial effort is underway to carry out the kinds of preparedness measures called for in Soviet manuals and other passive defense publications, the actual cost is likely to be higher than this estimate. Most of these measures, however, are restricted to relief efforts (clearing rubble, rescuing persons trapped in shelters, identifying radiation "hot spots," restoring water and sewer service, fire suppression, first aid, etc.). Given the basic inefficiencies in the Soviet economy, there is reason to believe that passive defense spending of

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[17] Some writers on Soviet civil defense point out that the Soviet national police of approximately 500,000 persons would be available to assist in civil defense work in an emergency, neglecting to mention, however, that federal, state, and local police forces in the United States number 400,000, according to an estimate by the Law Enforcement Assistance Administration. Emergency planning calls for their use in civil defense work in the United States, along with available National Guard and reserve forces. Moreover, the U.S. figure does not include police auxiliaries, private security personnel, or numerous other private resources, such as the Civil Air Patrol, ham and CB radio associations and volunteer relief groups which do not exist at all in Soviet society and which are not counted as emergency assets in the United States because they often lack official sponsorship.

[18] The apparent source for the estimate of one billion dollars in annual expenditures is a privately made extrapolation of what the Soviet Union would need to spend on this function to achieve its current program.

even two or three billion dollars per annum would provide relatively little in addition to this relief capability.

In an apparent effort to find an effective solution to the problem of population protection, Soviet civil defense programs have oscillated between sheltering and evacuation of urban dwellers. Following World War II, Soviet civil defense relied primarily on shelters in or near residential areas in the cities, probably as a result of lessons learned from strategic bombing in the war. Against a bomber-borne nuclear attack, shelters were thought to have some value, since the bomber's long time-to-target and peripheral Soviet radar defenses would provide adequate time to alert the populace and herd them into shelters. Later, as the Soviet population grew again and as the advent of intercontinental ballistic missiles shortened warning time (at least, confirmed warning), evacuation strategems appear to dominate Soviet civil defense planning. Manuals, which remain the primary source of information on Soviet civil defense plans and thinking, call for the populace to go to predesignated assembly points near their residences or places of work for movement to areas outside cities and beyond the probable radius of bomb damage and blast effects from weapons targeted on the city. At these more rural locations, the population would be sheltered from fallout in existing structures or in foxholes and "expedient shelters" which they built themselves from earth, timbers, or bundles of brushwood. Citizens would bring their own food supplies and would, apparently, be assisted by the government and by residents of these dispersal areas. Transportation of evacuees from the city to the dispersal areas would be accomplished by buses, trucks, autos, railway cars, and by foot. Evacuation would, of course, depend on warning in the form of a more or less protracted crisis which could permit authorities to order and carry out the mass movement of urban populations. Soviet sources indicate that city evacuation would require from three days to a week or more to accomplish.

This approach to population protection would appear to assume that the attacker will waste his weapons by attacking cities after they have been emptied, instead of attacking more "profitable" economic targets or the dispersed population (although the latter is not an optimum use for most nuclear weapons). It also appears to assume that the attacker would use all available weapons in a single exchange, instead of withholding a large reserve for the purpose of enforcing a protracted evacuation and hence social and economic disruption.

Perhaps because of the realization that evacuation plans so heavily depend on unreal assumptions about warning time, targeting, and usage of nuclear weapons, the Soviets appear to be turning back again to the concept of public shelters, primarily fallout shelters with a modest amount of "hardening" that would prevent damage from more distant detonations although not from direct hits. This approach, while permitting greater flexibility as to warning time, still requires some advance warning to be effective and involves far higher costs without assuring fully adequate protection. Moreover, no evidence has been presented to or reviewed by the committee that suggests the Soviets are either attempting or are able to provide this kind of protection for more than a fraction of the urban population.

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The major components of the Soviet industrial defense program are: (1) Dispersal of industrial capacity geographically; (2) permanent "safety" features, such as burial of cables and gas lines; (3) shelters for the labor force adjacent to plants; (4) some upgrading of structures to prevent their collapse as a result of near misses; (5) expedient measures for adding to the blast resistance of heavy machines by bulwarking them with dirt or other readily available materials; and (6) on-site reserves of materials to allow continuation of production. Rumored "movable" factories and wide-spread construction of underground plants could not be confirmed but in any case would provide little or no aid for recovery, despite very high costs, since they could be countered by: (1) sudden attack; (2) destruction in their new locations; (3) damage or inhabitability from the use of "silo-busting" warheads; or (4) destruction of vital links to the surface world (transportation, power, air supply, water, etc.). Relocation of Soviet industrial capacity east of the Urals during World War II was possible only because the eventual blunting of the German invasion allowed the time for this massive effort, which would not be the case in a nuclear war.

Allied with both the civil and industrial defense programs are training programs for both civil defense cadres and volunteers in first aid, radiation decontamination, disaster relief work, and related skills. For carrying out peacetime preparedness activities, planning and training and as a nucleus for wartime expansion, there exists the usual complex Soviet bureaucracy with civil defense staffs at all levels of government, somewhat akin to the civil defense and natural disaster elements at the local, state, regional and federal levels in the United States.

Analysis of the principal Soviet civil defense manuals reveals a heavy emphasis on saving lives and on relief operations, rather than on saving property. To judge from the content of these manuals, there appears to be an expectation that nuclear war will cause extremely heavy damage to material things and to human life but that some will survive, if advance precautions are taken and if relief efforts are rapidly and effectively mounted. The manuals, however, appear to have as a major aim preventing the demoralization of the populace in the event of nuclear attack. They seek to reassure Soviet citizens that, by their own efforts and with government assistance, survival is not only possible but likely. This goal at times involves mischaracterization of the capabilities and effects of nuclear weapons. For example, the second (1970) edition of "Grazhdanskaya Oborona" (Civil Defense) states, misleadingly:

> Immediate destruction of the enemy's means of attack is effected by antimissile and antiaircraft defense. Soviet air defense forces, coupled with the air force, and air defense troops of the ground forces and the navy, reliably protect our country from enemy strikes.
>
> However, it is not possible to guarantee that some of the enemy missiles will not penetrate our air defenses.[19]

[19] This handbook is used in technical educational institutions. A revised version issued in 1974 omits this passage as well similar rhetorical material, perhaps because of the intervening deployment of MIRV by the U.S. The revised version reveals basically the same civil defense plan with some changes in emphasis. See "Civil Defense," ORNL–TR–2845, prepared by the Oak Ridge National Laboratory, July 1975.

In view of the extremely limited ability of the types of defenses cited to repel submarine-launched or land-based strategic missiles, the passage quoted can only be taken as an effort to avoid an undermining of public discipline and social cohesion in advance. Similarly, Soviet civil defense programs call for the use of a pill supposedly effective against chemical, biological and radiological effects. Medical science in the West has been unable to confirm the existence of substances that would be capable of mitigating the effects of radiation poisoning in this way. These and other aspects of Soviet civil defense programs have led some expert observers to conclude that a major purpose of these programs is to provide the psychological inducements necessary to maintain the "mobilization" or "garrison" mentality that is typically associated with the preservation of totalitarian regimes. This requires continual reminders of external threats coupled with exhortations that discipline and correct action are necessary to defend against these threats.

Public injunctions and admonitions by prominent Soviet leaders about the necessity of maintaining strong civil defenses to support Soviet military forces appear to reflect efforts to sustain a "mobilization mentality," as well as a longstanding principle of Soviet strategy that relates victory in war to the adequacy of the Soviet political and economic structure.[20] This principle is an outgrowth of the Soviet Union's strategic position and its experience in World War II. It was first enunciated by Stalin in 1942 after the surprise German invasion. Unable to deny that the Germans had gained an advantage through surprise and better military preparations, Stalin discounted the ultimate effect of these advantages and held that victory in war was determined by a series of "permanently operating factors," among which was the strength of the communist state that supported the war effort.[21] The continued general relevance of this dictum, arising as it did from a particular set of circumstances in World War II, has long been questioned by Western strategists, who have held that, in nuclear war, the forces-in-being at the onset of war will determine its outcome, since there will not be adequate time to mobilize the economy or to bring to bear on the conflict the fruits of mobilization.[22]

Evaluation of Soviet Industrial Defense

Official pronouncements about current Soviet passive defenses have been characteristically guarded. However, public accounts of a preliminary National Security Council study conducted during 1976 disclose a recommendation not to effect major changes in the U.S. passive defense posture.

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[20] Leon Gouré, op. cit., passim, contains examples of these exhortations.

[21] A year after Stalin's death, Major General Nikolai Talensky, writing in "Military Thought," suggested that nuclear weapons could render the "permanently operating factors" meaningless. A debate in the pages of "Military Thought," ensued, ending in 1955 with the editors decreeing that ". . . it is not yet possible to propound any final and definite formulation of the basic law." Since that time, Soviet military writing on the subject of nuclear weapons strategy has been consistently ambiguous, perhaps reflecting uncertainties about the efficacy of "permanently operating factors" in the missile age. Nevertheless, public pronouncements have continued to stress the close connection between civil preparation and military victory, despite the ability of modern nuclear weapons to neutralize rear areas with relative impunity.

[22] Bernard Brodie, "Strategy in the Missile Age" (Princeton: Princeton University Press, 1965), pp. 207–210.

Defense officials, in public statements during 1976, expressed some skepticism about three aspects of the issue: (1) whether continuing Soviet investment in passive defenses represents a significant change from past practice; (2) whether such investment provides effective protection against U.S. forces; and (3) whether similar investment is necessary, appropriate or productive for the United States, given its different strategic situation.

> In countering a threat, it's not always necessary to counter that threat in kind . . . I would argue that it's not necessary to match them [the U.S.S.R.] in industrial dispersion and hardening, for example, nor may it be feasible. We have a totally different geography, a totally different situation here.—Dr. Malcolm Currie, Director of Defense Research and Engineering, February 1976.

> My judgment . . . is that we have an acceptable, healthy strategic deterrent today. There's no question but that the Soviet Union does in fact spend considerably more money and time and planning and energy in the civil defense area than does the United States . . . It is conceivable to me that at some point it would make sense for the United States, as we are continuing to review it, to continue to ask the question as to the cost and advantages to be gained by a somewhat higher level of interest on our part in civil defense. But, as of this moment, I think it's accurate to say that we have equivalence . . . in the case of accuracy, the United States has a clear superior position in the strategic element and there are other areas where they're [the Soviets] either roughly comparable or where they're ahead or we're ahead. The net is, and I think, that's what's important for the American to appreciate, the net is that we have a healthy, strong, nuclear deterrent today.—Donald Rumsfeld, March 1976.

> . . . there are, in fact changes in American strategic forces that could be adopted that would be directed at countering such a massive Soviet [civil defense] program, if there is one. The way to counter a relatively ineffective system is not to replicate it on the other side . . . The belief on either side that you can survive a strategic thermonuclear war as a going society—when you can't—is the worst possible situation for the world to be in.—Harold R. Brown, December 1976.

> At present the Soviet Union could not attack the United States without our being able to deliver a devastating retaliatory blow destroying the functioning of a modern society . . . I believe [Soviet] civil defense efforts can be overcome by retargeting [U.S. missiles] . . .—Harold R. Brown, January 1977.

> While the evidence is still coming in, and we cannot make firm judgments on either the magnitude or potential effectiveness of Soviet civil defense, the available information suggests a strong Soviet interest in damage limiting . . .

> while the Soviets may not persevere or succeed in this admittedly complex and difficult task, their growing capabilities must play a major role in U.S. force planning.—Donald Rumsfeld, January 1977.

The prevailing official doubts as to the utility of industrial or population defenses against a suitably structured nuclear attack are more emphatically reflected in the fact that neither the former nor the current administration has requested increases in funding for passive defense programs, following the resumption of intelligence coverage of Soviet civil defense in 1976.

While the evidence presented to the committee tended to indicate that Soviet industrial protection measures were far from complete, were selective in character, and were not uniform in terms of quality or effectiveness, it appeared prudent, for the sake of analysis, to assume that such programs had reached a high level of fulfillment. The following evaluation of overall effectiveness in protecting the Soviet economy from unacceptable damage in military, political and economic terms generally presumes measures far greater in scope than is actually the case.

1. Dispersal

Efforts to disperse Soviet industrial capacity have been prompted by two motives. The primary motive, which antedates World War II, is economic development of the more sparsely inhabited regions of the country, such as Siberia and the "Virgin Lands" territory. A secondary motive is to distribute productive capacity, especially that related to defense production, more widely so that there is less opportunity for "collateral" damage (from nearby detonations) and more aimpoints.

These dispersal programs have been uneven in their effectiveness. While resettlement appears to have distributed industrial production capacity more broadly, the establishment of new industrial centers in less populated regions appears merely to have created new targets without outrunning the increase in nuclear weapons available to target them. While Soviet planners have attempted to stem the growth of existing urban areas, they have generally been frustrated in this design. Between 1959 and 1970, for example, the aggregate population of the 58 leading Soviet metropolises (over 250,000 in population) increased by more than 30 percent while the total national population expanded only by a factor of 16 percent.

Other economic factors, rather than a simple interest in nuclear war dispersal, appear to determine the location of new facilities and new towns. Though some specialized facilities, such as those related to nuclear weapons production and the Soviet space program, have been separated from existing urban concentrations (as they have been in the United States), most siting is accounted for by normal economic considerations, such as development and proximity to labor, new or existing sources of power, markets, raw materials, and transportation. Among these factors, economic development and proximity to raw materials seem to be the most potent. New aluminum refining facilities and cellulose manufacturing capacity has been located near bauxite reserves and heavily forested areas.

Nor is there any evidence that the Soviet Union has given up its strong preference for achieving economies of scale by constructing huge industrial complexes—long a feature of Soviet development schemes. The Soviet Union boasts many of the "world's largest plants" in different types of industry—each presenting a particularly vulnerable target for nuclear weapons.

A meaningful industrial dispersion program requires that units of productive capacity be broken down into smaller production units and distributed to a larger number of more widely separated points. Only this kind of industrial dispersal can expand the number of targets, which is the aim of dispersal planning. Simply relocating large industrial complexes away from existing cities does not reduce their vulnerability to destruction by small numbers of re-entry vehicles.

Nevertheless, the Soviet Union chose to locate the world's largest aluminum plant and the world's largest timber-cellulose plant near the new Siberian city of Bratsk, where they would be close to supplies of raw materials and water but where they would also create especially "profitable" targets. Likewise, the facility which supplies the Soviet Union with 20 percent of its trucks—the Kama River Truck Plant, sprawling over 23 square miles and connected by 175 miles of computer-controlled conveyor belts and assembly lines—provides an equally rewarding series of vulnerable, high-value targets. Construction of the sprawling Volzhsky Auto Works (presumably a source of trucks or tractors under wartime conditions) at the new city of Togliattigrad presents another case in point. At the same time, instead of relocating the productive capacity of the antiquated Moscow Ball Bearing Plant No. 1 at a number of dispersed sites away from the capital, Soviet planners chose to refurbish the existing structure in the Moscow suburbs, thereby preserving as a single target an especially critical element of an industrial economy.[23]

Another aspect of dispersal is the wider separation of elements in a production sequence within a given industrial complex. Such dispersion within a plant would likely have some benefits in terms of reducing damage to certain segments of the production chain. Whether dispersal of the various elements of production within a given plant site in the U.S.S.R. is the result of defensive considerations or simply of other considerations in plant design is difficult to say. In any case, the net benefit is likely to be small, since destruction of a vital link in the production chain will seriously impede the return to full production, even if other links survive. In terms of the military acceptability of economic damage, it is important to remember that what counts is not the simple survival of equipment or structures but rather the capacity to employ that capacity effectively. If, through lack of adequate labor, power, raw materials, essential equipment, or transportation facilities, a major complex is unable to produce at an appreciable volume for an extended period, it can be considered lost

[23] In contrast to the United States, moreover, the Soviet Union does not have the dispersal and redundancy that exists in the United States as a result of small manufacturing enterprises (machine shops, tool-and-die manufacturers, iron-works, steel fabricators, etc.) in small cities and towns throughout the country. Likewise, repair facilities for machinery and automotive equipment are far more widely dispersed in small units in the U.S.

to the war effort or to the effort to support essential civilian needs, even though material damage may be limited to only one aspect of the production complex.

More significant, however, is the impossibility of dispersing (under any definition) certain facilities that are of fundamental importance to the productive system and the economy generally. Several types have already been mentioned: hydroelectric plants, transportation facilities of all types, and petroleum refineries. On balance, dispersal for nuclear defense purposes does not seem to have proceeded very far in the Soviet Union, probably because of the great diseconomies of locating production capacity far from labor, materials, power and transportation and of disaggregating large industrial complexes. At the same time, dispersal, even if carried out well beyond current levels does not ultimately offer much protection from the current generation of nuclear weapons, given the accuracies of these weapons and the remaining highly vulnerable elements of the total economic system.

2. Equipment protection and materials reserves

Many of these same considerations apply to the effectiveness of plant and equipment protection measures. While certain kinds of plant and equipment lend themselves to industrial defense by strengthening structures against shock, burying utility lines, installing emergency generators, and last-minute bulwarking of individual machines, a vast number of other, equally vital types of industrial facilities do not. Protecting those plants which can be afforded some degree of protection merely serves to encourage a potential attacker to realign his target plans to encompass the largest number of unprotectable, high-value targets.

Moreover, should there exist more or less protectable facilities of particular interest to the would-be attacker, most of the measures being pursued by the Soviet Union provide little protection against direct hits by MIRV warheads. The net benefit, then, of both permanent measures (improving structural soundness, eliminating obvious fire and blast hazards, duplicating and burying cables and pipelines, etc.) and expedient measures (covering equipment, shutting off power, etc.) is to reduce the collateral damage to adjacent structures and equipment from direct hits on nearby facilities. Since, as former Defense Secretary Rumsfeld noted in remarks quoted earlier, U.S. weapons have been designed to maximize the effects of direct hits and to minimize collateral damage, the Soviet Union is protecting itself primarily against a class of "bonus" destruction which U.S. planners no longer consider necessary to the achievement of unacceptable industrial damage.

For those few vital facilities which may be hardened by underground emplacement, the attacker has the options (1) of ignoring them in favor of equally vital but unprotectable surface targets, (2) of committing additional warheads in order to "dig out" such facilities or (3) of seeking to destroy surface connections for the supply of air, water or materials.

Finally, many of the expedient protection measures are stand-by in nature, that is, they will require a certain number of days of warning time to implement them. If the warning time is not available, these

measures are of no use. If adequate warning is provided, execution of these measures will entail the halting of production for so long as the attacker retains a reserve of warheads, thus achieving the same effect as actual damage in terms of reducing Soviet productive capacity.

As regards Soviet reserves or stockpiles (of raw materials, fuel and components required to sustain production after damage to transportation systems or sources of supply), there does not appear to be any evidence on which to base a judgment as to whether these reserves are greater in size than is dictated by normal manufacturing requirements. In the United States, for example, most processors of raw materials maintain on hand as much as a 30 to 90 day supply of materials in order to permit the optimal use of productive capacity despite delays or temporary shortages in supply.[24] In the Soviet Union, the practice of "storming" would suggest even more strongly to the managers of processing plants the advisability of maintaining high inventories of basic materials so as to ensure adequate stocks in the face of uneven supply.

The advantage of these reserves of basic materials, or even of inventories of semi-finished goods and components, will be of little avail if the productive and distributive systems which employ and transport them have been seriously damaged. Their significance in tiding an economy over after a nuclear attack can also be reduced or nullified, if the sources of such materials are cut-off through the destruction of highly vulnerable petroleum refineries and petrochemical or other initial refining plants or through targeting of mineral mines.

Because of the long lead-times required to turn basic materials into end-use items, the primary value of materials reserves and inventories of semi-finished goods lies in assisting post-attack economic recovery, not in prosecuting an immediate nuclear war effort or carrying out relief and reconstitution programs. Accordingly to one study,

> In aggregative terms, the process of achieving [economic] viability can be viewed as a race between the reconstruction of the capital stock (and thus the recovery of output) and the depletion of the inventories from which essential needs are being met in the meantime.[25]

The direct and immediate military value of these stockpiles, however, is very limited, since a thermonuclear war, even one lasting several months, is likely to be terminated before products fabricated from such stockpiles enter into use in any significant degree. If the means of turning such stockpiles into finished products are heavily damaged or destroyed, their utility is degraded still further.

3. Labor force

Industrial defense requires that a significant portion of the labor force escapes death, injury and debilitating disease, for without a pool of skilled labor no modern industrial nation can maintain production at levels required to sustain its economic power, meet essential

[24] In addition, the U.S. government maintains large strategic materials stockpiles for wartime mobilization.
[25] Winter, op. cit., p. vi.

civilian needs, and support a meaningful defense. Survival of large numbers of healthy, working age citizens becomes even more important in view of the fact that, in the post-attack period, labor will have to be substituted in large quantities for equipment and power lost in any nuclear exchange. In some measure, economies which have been more capital-intensive will revert to labor-intensive techniques for an extended period after an attack.

To protect the work force in a nuclear attack, Soviet plans apparently call for shelters at critical plants for a portion of the workers (probably an expanded shift) and for dispersing the remainder to sites away from urban targets but close enough to industrial facilities to permit workers to walk or be transported back to their jobs when it becomes safe enough to do so after a nuclear attack. Industrial shelters combine protection against fallout with some protection against blast effects if nuclear weapons are not detonated in the immediate vicinity of the shelter. Soviet manuals also detail measures for providing some protection to workers who must stay by their machines where the equipment cannot be shut down even during nuclear attack.

Assuming relatively little radioactive fallout, workers will be able to leave their shelters or dispersal sites and return to work for longer and longer periods, according to Soviet manuals, as decontamination operations reduce radioactive "hot spots" and normal wind and weather conditions reduce the general level of radioactivity.

It is not clear from Soviet manuals how the labor force will be supported during the relief, reconstitution and recovery phases. If the surviving pool of workers is to continue to be an effective part of the productive system, it will require shelter, medical support, and foodstuffs on an uninterrupted basis and at more than the minimum sustenance level which will be the likely lot of the general population. Industrial recovery after nuclear attack will necessitate greatly increased productivity from each worker to compensate for losses in capital equipment and in the labor force itself. This means longer shifts and/or shorter shift breaks. Under these circumstances, workers will require increased caloric intake but will be unable to provide for any of their own basic requirements. Thus, neither dispersal nor blast and fallout shelters represent in themselves complete answers to the formidable task of protecting, supporting and reorganizing the labor force following a nuclear attack. Typically, Soviet manuals and handbooks are silent on these larger problems that will have to be faced after immediate relief operations have been carried off.

In terms of the immediate problems, however, it does not appear that the labor force on duty at specifically targeted industrial facilities will escape destruction, even if fallout-blast shelters are fully utilized, since they do not afford protection against direct hits. The dispersed portion of such a plant's labor force will likely survive but will probably have no plant to return to, at least not one capable of returning to production at any early time. Moreover, American analysts have expressed considerable skepticism about the efficacy of Soviet industrial shelters. Commenting on changes in the 1974 version of "Grazhdanskaya Oborona", U.S. editors at Oak Ridge National Laboratory observed:

> [The book] gives the requirements (space and seating arrangements, water supply, heating, ventilation, sanitary facilities, etc.) for the bomb shelters constructed during peacetime for workers and employees of industrial enterprises. The requirements have not changed from those in the old manual, even to the minimum requirements for air supply. This leads one to suspect that the Soviet Union has not conducted mass shelter living experiments or even simulated ones as has been done in the U.S. They claim . . . that when the air supply operates on the filtration mode, $2m^3/hr.$ (1.1 cfm) of air is sufficient for control of carbon dioxide, and when operated in this mode, "heat is absorbed by the shelter exterior structures, as a result of which the air temperature and humidity do not exceed allowable limits during the course of a specified period of time."[26]

In the estimate of the Oak Ridge analysts, these technical miscalculations about the adequacy of the fresh air supply in Soviet shelters represent ". . . the most serious flaw in the whole Soviet Civil Defense planning." As with any underground structure designed to protect humans over extended periods, the Achilles heel is the air filtration system, which must ventilate to the surface where it is subject to blast effects and, possibly, radiation contamination, even if it is adequate for air circulation and filtration in the first place. The very close proximity to industrial facilities constitutes the primary weakness of this kind of shelter for protecting the labor force, since it makes the workers nearly as vulnerable as the plants themselves to an industrially-oriented nuclear attack. An attack designed to destroy a large and important industrial facility with two or three re-entry vehicles, would place such shelters at or near ground zero. Under such circumstances, shelters might survive but not the workers inside them either because of the resulting fire storm and lack of oxygen or because of radioactivity.

Even in the event that the workers could survive this type of attack, there would be no surviving industrial facility on the surface for them to return to. Moreover, while shelters adjacent to industrial facilities can be occupied after only very short warning (or even after onset of an attack, if weapons detonations are distant), casualties and fatalities among the off-duty workers may be high, if warning time is inadequate to permit their evacuation and if population centers are deliberately targeted.

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The most important feature of Soviet industrial defense programs is that they lack the effectiveness necessary to prevent severe damage to industrial facilities by present-generation nuclear weapons. Although some facilities will be able to achieve more protection than others (due to the differing nature of industrial and allied processes), none can achieve protection sufficient to avoid penetration and destruction by presently available U.S. weapons, even if Soviet programs based on current technology are pursued far more extensively and vigorously than is now the case. Under optimal conditions (in terms of weather, advance warning, shelter habitability, transportation avail-

[26] Civil Defense, 1974 version, op. cit., p. vi.

ability, and other factors), Soviet industrial defenses are limited to reducing the amount of "bonus" damage to facilities adjacent to directly targeted elements and to preserving some portion of the labor force. In other words, the primary benefit of Soviet protection measures is to reduce the collateral damage to nontargeted facilities. Since the criteria for the destruction of Soviet industrial capacity in a retaliatory attack can readily be met by current U.S. force loadings (without the necessity for including collateral damage through side-effects), this low-level protective capacity is of marginal significance.

In general, then, Soviet passive defense programs are effective only for facilities not directly targeted in a U.S. retaliatory attack. At this level, Soviet measures fall far short of being able to deny the U.S. the capacity to inflict devastating damage on the Soviet economy and therefore on its warmaking capacity.

Evaluation of Soviet Population Defense

Though the committee's primary interest in Soviet passive defenses was restricted to industrial protection, population defenses were evaluated as another index for gauging the overall effectiveness of Soviet passive defenses. Moreover, population protection bears an important relationship to protection of the economic infrastructure, since imbalances between surviving population and surviving economic capacity can significantly increase the immediate burden on the latter and thereby retard overall recovery.

The territory of the Soviet Union covers 8.65 million square miles (8,649,489 million square miles or about 6.53 million square nautical miles), some half of which is cultivable, while much of the remainder consists of uninhabited treeless wastes or frozen tundra. Three per cent of Soviet territory (a figure sometimes used for describing the aggregate destructive radius for U.S. weapons) amounts to 259,484 square miles or 195,000 square nautical miles—nautical miles being a standard measure for calculating weapons characteristics and effects.

The total area of the 50 largest Soviet industrial centers is only 3,000 square nautical miles or a minute percentage of the total Soviet territory vulnerable to U.S. strategic forces. In 1976, a Defense Department official stated that 300 megatons would be adequate to destroy structures in an area as large as 4,300 square nautical miles.[27] Allowing for a 10 percent rate of operational failures and misses, 330 of the early, unMIRVed, one-megaton Minuteman II missiles could cause heavy damage to the top 50 Soviet cities without support from submarine-launched Polaris/Poseidon missiles, the Minuteman III (MIRVed) and Titan (unMIRVed) ICBMs, or U.S. strategic bomber forces, assuming the United States returned to targeting of population centers. Similarly, 150 more missiles would create this level of damage to all 200 Soviet cities with populations over 50,000.

In order to avoid extremely high fatality and casualty rates from the prompt effects of such nuclear salvos, the Soviet Union would need

[27] Mr. John B. Walsh, Deputy Director of Defense Research and Engineering for Strategic and Space Systems, "Hearings on Military Posture and H.R. 11500, Department of Defense Authorization for Appropriations for Fiscal Year 1977," Committee on Armed Services, U.S. House of Representatives, Part V, p. 122. Blast overpressure of 2 pounds per square inch (psi) is equivalent to a high force hurricane; frame structures are leveled at 4 psi and structures with steel skeletons at about 5 psi.

to (1) be able to empty its cities completely or (2) provide very heavily hardened and accessible blast shelters for a very high percentage of its urban population. Warning time of at least three days would be required, according to Soviet civil defense manuals, to carry out the first option and there is room for skepticism about the existence of the ideal conditions required to meet this deadline.[28]

As to the second option, changes in the Soviet civil defense handbook between the 1970 and 1974 versions indicate a greater reliance on shelters as contrasted with evacuation planning.[29] This appears to stem from a realization that warning time for evacuation may not be adequate for success. The greater stress on shelters, however, is connected primarily with blast-fallout shelters for industrial workers. The use of basements and subways, where they exist, is recommended for urban blast protection and the utility of other structures for fallout protection is noted.[30] Yet neither Soviet manuals nor evidence available on actual shelter programs suggest that the Soviet Union believes it can provide adequate blast shelter protection for all of its major urban populations. Indeed, various versions and editions of Soviet civil defense handbooks reflect vacillation in the face of the dilemma posed by uncertainties about warning time for evacuation and the impossibility of providing adequately hardened and readily accessible blast shelters for millions of urban dwellers.

Assuming that blast shelters could be hardened to a degree effective against present generation nuclear weapons and could be made accessible to a very high percentage of the citizenry, their cost would be very high even for a government willing to invest a great deal of capital in civil defense. In 1956, Administrator Val Peterson of the Federal Civil Defense Administration recommended against evacuation plans as fruitless efforts at "outrunning the bomb" and proposed a program of blast shelters at a cost of from $30 to $50 billion.[31] In 1957, the Gaither Committee, on the other hand, recommended against

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[28] Using Soviet manuals and public announcements as criteria for judging the effectiveness of Soviet programs, may lead to serious misjudgments and overstatements. The parallel publications of the United States, for example, give a very misleading impression of the breadth and depth of American programs. One recent series of elaborate and impressive studies on evacuation contained the following titles: "Guide for Crisis Relocation Contingency Planning"; "Food System Support of the Relocation Strategy"; "Reception/Care Planning for Crisis Relocation"; "Prototype Reception/Care Plan to Meet the Welfare, Shelter, and Related Needs of Populations Affected by Crisis Relocation"; "Prototype Plans for Production and Maintenance of Electrical Power in Crisis Relocation."

Another manual entitled "Disaster Planning Guide for Business and Industry" contained a checklist of nuclear attack procedures that was not only quite detailed but indicated that considerable resources were available to assist management in preparing, exercising and carrying out measures for protecting the labor force in the event of a nuclear attack.

[29] For a discussion of the feasibility, effectiveness and desirability of crisis evacuation, see Jeremy J. Stone, "The Question of Crisis Evacuation," Annex I to "Arms Control and Civil Defense," prepared by the Hudson Institute for the U.S. Arms Control and Disarmament Agency under contract ACDA/IR–10, August 20, 1963. Based on a 1963 GNP of $550 billion, the author estimated that evacuation would cause the U.S. losses from economic disruption alone of $1.5 billion per day. Evacuation, especially if extended, reduces a nation's economic strength, even if no nuclear attack occurs. For a study of counterevacuation as a means of reducing the putative bargaining leverage of a Soviet city evacuation, see "Strategic Considerations in Planning a Counterevacuation," by C. V. Chester, G. A. Christy, and C. M. Haaland of the Oak Ridge National Laboratory for the Energy Research and Development Administration, 1976. (Printed by the National Technical Information Service.)

[30] Some subways, such as in Tashkent and Kharkov, would be too shallow to provide much blast protection.

[31] Anthony J. Wiener, "The Domestic Political Interactions," Annex IV to "Arms Control and Civil Defense," prepared by the Hudson Institute for the U.S. Arms Control and Disarmament Agency under contract ACDA/IR–10, August 20, 1963, p. 3.

a nation-wide program of blast shelters for the urban population of the United States in its report "Deterrence and Survival in the Nuclear Age," estimating that the cost of such shelters would run to $55 billion and their effectiveness would be limited.[32] Given the increase in the urban population of over 50 percent and the 147 percent increase in heavy construction costs between 1957 and 1975, as well as increases in lethality and number of re-entry vehicles, a conservative estimate of the cost of a similar blast shelter program today would be $200 billion and would take many years to complete.

The relatively greater emphasis on protecting the labor force suggests that Soviet planners view this as a somewhat more soluble problem. In any case, assuming an attack directed at cities per se (not primarily provided for in U.S. targeting), the destruction of housing and other essentials of human life would levy enormous burdens on the already weak Soviet economic infrastructure, especially if most or all the population survived through evacuation and required long-term support. Even in peacetime, for example, and despite the commitment of considerable resources over several five-year plans, Soviet housing continues to be unable to keep up with demand. To wait several years for an inadequate apartment is even now a very common occurrence.

Earlier versions of the Soviet civil defense manual claimed that civil defense measures, if properly prepared and executed, might protect as much as 93 to 95 per cent of the urban population, reducing fatalities from prompt effects to about ten million human deaths, or an immediate loss equivalent to half what the Soviet Union lost in four years of World War II. These estimates include only immediate fatalities; they do not include the additional fatalities and casualties from burns, radiation poisoning, exposure, stress, panic, flying debris, fires, smoke, or lack of adequate food, clothing and shelter (particularly among the elderly).

Casualty and fatality estimates are inherently speculative, however, because they involve so many assumptions and unknowns (about such things as radiation poisoning, for example).[33] Soviet and American estimates must therefore be regarded with considerable reserve. Uncertainties about the adequacy of their protective measures may have caused the Soviets to eliminate estimates from later civil defense literature.

Nine per cent of the total Soviet population, or 22.8 million persons, is concentrated in the eleven major urban-industrial areas of Moscow, Leningrad, Kiev, Tashkent, Kharkov, Gorky, Novosibirsk, Kuibyshev, Sverdlovsk, Minsk and Odessa. Citizens are far more densely concentrated in these cities than in the United States, as a result of Soviet housing and transportation patterns. There are over twice as many people per square mile (11,000) in the 50 largest Soviet cities than there are in the 50 largest American cities (4,600 per square mile). Although most U.S. warheads are not optimal for population attacks, a devastating economic-and-population attack could be designed against these eleven cities alone, if the Soviets are not per-

[32] Reprinted by the Joint Committee on Defense Production, 94th Cong., 2d sess. (Washington: Government Printing Office, 1976).

[33] For example, Department of Defense estimates of U.S. casualties from "limited" nuclear attacks alone ranged from 800,000 to 16.3 million with the maximum figure twenty times the minimum one. The estimates of Soviet fatalities cited above presume ideal protection factors against unlimited nuclear attacks.

mitted the three to seven days required for urban evacuation. Soviet shelters would provide marginal protection for only a fraction of the populations of these cities. Even without the reserve of Quick Reaction Alert forces capable of reaching targets in the U.S.S.R., it has been estimated that the U.S. inventory of strategic nuclear forces is sufficiently large to permit targeting all 3,000 Soviet towns down to the 5,000 to 10,000 population range, where there are no shelter facilities.

In order to achieve the results claimed for them, Soviet evacuation plans, moreover, would require training and exercising of the labor force and the general populace in advance of their implementation. Without training and exercising, the predicted times for achieving complete evacuation would be considerably degraded and evacuation could be considered only as a "last resort" measure to be relied on only in the most desperate circumstances.

While Soviet citizens, through their residential leaders (building superintendents and block captains), are informed of their role in evacuation, travellers who have discussed these matters with citizens indicate that there is widespread skepticism about civil defense measures for the general public. This kind of disbelief can itself have a negative effect on evacuation implementation. More importantly, training and drills of the magnitude necessary to execute evacuation rapidly and with a high degree of effectiveness would be visible to the casual observer. Yet evidence of this kind of evacuation exercise in major Soviet cities, such as the eleven mentioned earlier, has been lacking. Moreover, a nationwide exercise of evacuation plans (the only fully effective method of testing their utility) is unlikely, since it might prompt the United States to believe that the Soviet Union was contemplating an attack.

Such training of the general population as is called for in the Soviet civil defense program is restricted to a few hours in basic measures (first-aid, decontamination, gas mask instruction, and other life-saving skills) each year through the regular school curriculum. The only other training program of broad scope is the survival training which Soviet youth receive during regular summer physical fitness camps, which stress the military utility of sports and physical training. Neither of these programs appears to be especially suitable to conducting mass evacuations per se, though doubtless they would be of some utility in the course of relief operations where evacuation is unsuccessful.

Population protection and expedient industrial defense measures, such as Soviet civil defense calls for, involve large and complex logistical problems, even if weather and advance warning conditions are satisfactorily met. Some of the difficulties in solving these problems have been summarized in a recent Congressional Research Service study by Col. John M. Collins, USA (Ret.):

> Frequent complaints in Soviet publications about apathetic administrators and poor civil defense planning suggest that there are "considerable variations in the initiative and interest . . . by the chairmen of city executive communities." Factories, villages, and collective farms rehearse their roles occasionally, but that is a far cry from full-scale exercises involving entire cities.

> Take Moscow as just one instance, a center of seven million, to cite the latest census. Perhaps half would depend on rail, the principal mode of transport, "for mass emergency movements" (175 trainloads of 100 cars each, packed with 20,000 persons). Forty percent or so would rely on motor vehicles—buses, trucks, and private automobiles. The remainder would board aircraft, river boats, or flee on foot. Marshalling mandatory conveyances and coordinating groups of such size would create colossal problems. "The entire able-bodied population" would be called on to construct hasty fallout shelters in reception areas, since those currently available are insufficient to accommodate rural inhabitants and a spate of arrivals from cities.
>
> Simultaneous mass movements elsewhere in the Soviet Union would create staggering economic and social problems attendant to feeding, housing, and ministering to millions of displaced persons during periods that could be prolonged. If evacuation were ordered in winter, severe cold would complicate matters immensely.
>
> No one as yet has satisfactorily answered hard questions, such as:
>
> How would evacuating people from cities ensure Soviet survival, if the production base that sustains them were smashed?
>
> How would permanently displaced people survive if many cities of residence were destroyed?
>
> How could evacuees escape heavy cumulative casualties if U.S. saturation attacks used MIRVs en masse against many reception sites at an early stage?
>
> How could anything less than full-scale evacuation cut casualties during a limited nuclear war, unless the Soviets knew in advance which cities/areas we would strike?
>
> Plausible explanations are essential. In their absence, U.S. leaders risk crediting the Soviet Union with CD capabilities that result in considerable part from rhetoric.[34]

The author concluded that Soviet civil defense measures were ". . . impressive on paper—how practical they would be in practice is problematical."

* * * * * * *

When viewed in the context of the requirements for effective protection against U.S. retaliatory attacks, Soviet passive defenses do not bear out the contention that they could deny the United States the ability to create economic or population damage to the Soviet Union that would be considered unacceptable to any but an irrational or desperate leadership. Nor does it appear that Soviet planners believe they are near defensive solutions to the many and complex problems posed by today's nuclear weapons. Changes in the emphasis of Soviet programs tend instead to indicate large uncertainties about the effectiveness of existing measures, despite persistent Soviet efforts to reduce or overcome these basic economic and population vulnerabilities.

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[34] "United States and Soviet City Defenses, Considerations for Congress," Senate Document No. 94-268 (Washington: Government Printing Office, September 1976), p. 15.

The intentions that lie behind this persistent effort are a separate matter. Generally speaking, sheer military resources, as well as civil and industrial defenses, are very poor indices of intentions.[35] The explanation for Soviet passive defense programs cannot therefore be found simply in a review of its limited civil and industrial defense programs but must be explained by the evolution of these programs and through the particular Soviet perceptions of its strategic requirements.

Soviet Motivations

Nothwithstanding the inability of Soviet passive defense programs to thwart a U.S. nuclear retaliation, the reasons for Soviet persistence in maintaining programs of extremely limited utility against strategic attack remain of interest. Several types of strategic and non-strategic motivation have been suggested.

Strategic Motivations

Aggressive attack

This is the most malevolent motivation and assumes that the Soviet Union is planning to achieve some or all of its declared goal of world-wide communism by unleashing a nuclear surprise attack on the United States, its major adversary, and passive defenses are part of the preparations for such an attack.

Diplomatic crisis

There are two variations on this imputed motiation. One assumes that the Soviet Union intends to *promote* a crisis, through demands for some unspecified economic or political concession, and expects to be able to back up such demands by calling attention to the ability of its passive defenses to thwart any attack that the United States might threaten in return. A variant of this motivation is that the Soviet leadership believes that, in a future diplomatic crisis of whatever origin, its passive defenses would give it bargaining leverage over the United States, again because of the asserted Soviet capability to thwart a U.S. retaliatory attack.

Prudential measures

This assumes that the Soviet Union is by now aware of the impossibility of developing passive defenses effective enough to deny the United States its retaliatory capability but is nevertheless willing to commit resources to passive defenses for a variety of related motives, such as: (a) a hedge against an aggressive American attack, in order to reduce damage if it cannot escape most of it, (b) a hedge against "theater nuclear forces" maintained by the United States and its N.A.T.O. allies in Europe, (c) a hedge against a desperate attack by a lesser nuclear force, such as China's or France's *force de frappe*, and (d) for the protection of some residual war-making capacity, so as to be able to defend its territory and client states against defection or

[35] Based on its long and continuing lead in separately targetable, thermonuclear weapons, for example, the United States might be considered the most threatening and warlike nation in the world today, if intentions are considered to be perfectly congruent with strategic forces. On the other hand, U.S. de-emphasis on passive defenses might, equally mistakenly, be misconstrued as a total lack of desire to defend the United States against nuclear attack.

occupation (from China or West Europe) following an American nuclear attack.[36]

Non-Strategic Motivations

Among the non-strategic motivations for passive defense programs, some of which have already been suggested, are: (a) a very low tolerance for external threats, (b) the institutional momentum that infects the programs of all large, complex organizations, (c) the need to assure internal discipline and control by promoting and maintaining a "garrison" or "mobilization" spirit among the populace through invocation of foreign threats, (d) a concession by the Politburo to the Soviet military leadership in return for support of arms control agreements, and (e) psychological reassurance during an extended period of perceived strategic inferiority.

All explanations are in substantial agreement that the Soviet military and political leadership does not want nuclear war and will go to considerable lengths to avoid it. As a means of achieving long-term world domination, nuclear war would be futile or counter-productive, since (a) the Soviet Union lacks the resources to follow up a nuclear attack with a trans-oceanic invasion or occupation of the United States, (b) a nuclear attack would create outraged and implacable foes, not docile converts, and (c) the Soviet strategy for accomplishing world communist pre-eminence involves political subversion with the minimum risk to gains already made by the Soviet Union.

The notion that the Soviet Union would attempt to use a combination of nuclear weapons and passive defenses to extort concessions from the West lacks plausibility. To do so with any hope of success would require a passive defense capability that is beyond Soviet means. Such an effort could not be risked with passive defenses that would be only partly successful, since the Soviet leadership would run the very real risk of having its bluff called, with severe consequences for Soviet power.

Moreover, amid the current speculation about the motives for Soviet passive defense programs, no realistic or credible political scenario has been offered that postulates a political or economic goal of such overwhelming importance to the Soviet Union that it would risk sacrificing its current economic status and political role to obtain this end.

As to the question of gaining diplomatic leverage in a crisis situation that was *not* necessarily of Soviet making, the difficulties of carrying out such a game of bluff become even more salient, because the Soviets have even less control of vital variables. Although the hope of being able to use passive defenses as an "equalizer" against the American preponderance in strategic weapons was no doubt a potent motive for Soviet planners in an earlier period, particularly following the Cuban missile crisis of 1962, the realism of this motivation must be reassessed in light of the changing complexion of strategic nuclear forces over the last 15 years.

In any case, Soviet passive defenses are not of a kind that gives them the flexibility to manipulate them as a bargaining instrument, when Soviet leaders do not control timing or other factors in the

[36] Soviet war-planning must contend with the fact that there are four nuclear forces which could initiate attacks against the Soviet Union (albeit of varying intensities): France, Great Britain, the United States and the Peoples' Republic of China.

crisis. If, for example, a diplomatic crisis or confrontation takes place in the winter months, Soviet evacuation plans are of no use and industrial equipment protection plans are similarly subject to the vagaries of climate and weather. (Machinery cannot be bunkered with earth if the earth is frozen; plants where equipment survives but roofs are blown off will not provide a practical environment for Soviet workers in the winter months, especially on the night shifts, which are considered essential for the Soviets to maintain any meaningful productivity.)

Quite aside from the continuing vulnerability of "unprotectable" industrial facilities (refineries, etc.), Soviet agriculture would remain totally exposed to American attack on the Soviet agro-hydraulic system. Finally, as was noted earlier, the kind of bargaining leverage provided by passive defenses would be believable only once, if it is believable at all. Should the United States fail to be bluffed, the Soviet Union must either back away from its threat and suffer an enormous loss of prestige or it must carry out its threat to attack and suffer devestating damage and long-term impoverishment as a consequence. In either event, there will be no second chance to gain diplomatic leverage from passive defenses.

Program Momentum

In assessing other motivations for maintaining civil and industrial defense programs, it is important to remember that the current Soviet programs had their origin in the immediate aftermath of World War II. Many of the population shelters that exist today were constructed during this period, though they have been upgraded in the interim, and many of the measures for protecting industrial machinery originated in the Soviet experience in trying to maintain some of its industrial base after the German invasion of June 1941.

As a result, there is a significant capital investment in passive defense programs, as well as a psychological and institutional investment. Although qualitative and quantitative improvements in strategic offensive forces have far outstripped any improvements in passive defense techniques, there is an understandable reluctance to simply writing off this substantial sunk investment in time, labor, and resources. Rather, the tendency in large organizations is to try to adapt obsolescing or outmoded programs involving large amounts of unrecoupable investment to changing circumstances though additional commitment of resources.

Moreover, during the 1960s when the advent of the missile era injected a new stimulus in passive defense programs, it was unlikely that Soviet planners could have clearly foreseen the kinds of strategic weapons advances that have reduced still further the utility of passive defenses. Chief among these advances has been the introduction of MIRVs, which greatly increase the destructive power of a given number of launchers and at a relatively small cost. At the time the Soviet industrial defense programs were undergoing considerable growth, the weapon which could overcome these defensive measures was already being tested at American missile ranges. The Soviet civil and industrial defense program, however, are largely pre-MIRV in character; that is, they are designed to be effective against strategic forces far

less capable than MIRVed missiles, deployment of which occured relatively recently, beginning in 1971.

It is possible, however, that the Soviet shift, recently detected by some observers, from stressing evacuation plans to emphasis on blast shelters for urban populations reflects an awareness that MIRVs could also be effective against all but the most widely dispersed populations and reflects a desperate effort to cope with this situation.[37]

It seems unlikely, however, that there will be any appreciable slackening in the steady growth of these Soviet defensive programs in the years to come. Other motivations for maintaining the programs are likely to provide the necessary justification for retaining them.

Other threats to the U.S.S.R.

Several of these motivations stem from the quite different strategic situation of the Soviet Union, as compared to the United States. The existence near Soviet borders of other and potentially hostile nuclear powers, which are not possessed of MIRVs, and the possible advent of new nuclear-weapons nations, such as India, suggests that retention of passive defense programs would be a prudent course, since these programs would continue to be effective against smaller, non-MIRVed nuclear forces for a good many years in the future.

The remarks of former Defense Secretary Rumsfeld regarding Soviet conventional forces in the *Annual Defense Department Report FY 1978* are applicable to the strategic nuclear situation as well:

> The Soviet capabilities show an appreciation of the importance of conventional strength, and reflect a determined, sustained, and increasing effort to develop two conventional forces—one facing Europe and the other opposite China.

Because the Soviet programs are to some extent already bought and paid for, it would seem equally prudent to maintain them in order to limit, as best they can, the damage that would result from what the Soviet leadership no doubt perceives as a possibility—an aggressive, first-strike by the United States. While the damage-limiting ability of these programs is, as noted earlier, very restricted, there seems to be no compelling reason to forego whatever life-saving benefits these programs can confer on the populace, even if they are inadequate to deny the major effects of a U.S. retaliatory attack on military and industrial targets.

In this same context, while protection of industrial equipment would not prove fully effective against the kind of attack which U.S. forces are capable of, it could lessen to some extent Soviet vulnerability to other external threats in the aftermath of an American first strike. Any assessment of Soviet motivations must thus take into account the fact that the Soviet leadership is, or perceives itself to be, vulnerable to hazards that simply do not apply to the United States, such as loss of border territories or erosion of the protective belt of client states or, least likely, invasion across its broad plains. These additional vulnerabilities not only have a direct impact on Soviet offensive

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[37] As early as 1957, the Gaither Committee in the United States deemed evacuation and dispersal as "unacceptable alternatives." See Appendix B to the previously cited report of that committee.

and defensive programs, they influence as well the broader perceptual environment in which Soviet decisions are made, reinforcing the longstanding Soviet emphasis on defensive measures.

Moreover, Soviet planners must contend with the reality of Soviet vulnerability to U.S. theater nuclear weapons, which have been maintained at a fairly steady level of 7,000 nuclear warheads in Europe for more than 10 years. While American planning rests on the assumption of a Soviet or Warsaw Pact attack in Europe, Eastern military planners must look at the other possibility—an attack by Western Europe, perhaps led or instigated by an increasingly strong Federal Republic of Germany. However unlikely such an event may seem to Westerners, it is doubtless a central contingency for Soviet war planning.

European passive defenses

Discussion of Soviet passive defenses would not be complete without mention of the civil and industrial defenses of other European nations. First, it is important to note that Warsaw Pact nations have begun to adopt the kinds of defenses that the Soviet Union has been developing for the last 15 years or more. Since there are relatively few "strategic" targets in these countries (in the sense that they would be more attractive to American strategic target planners than military and industrial targets in the Soviet Union itself), this suggests the prudential or European-conflict orientation of Soviet passive defenses.

Moreover, the high and continuing interest in civil defense by certain Western European nations is illustrative of the increased willingness of nations which have been invaded or threatened with invasion to expend resources on passive defenses, even though these defenses would ultimately be no proof against a determined adversary.[38]

Switzerland, for example, has long maintained an extensive passive defense system, including provisions for hardening essential factories, power facilities, and military targets. Civil defense training is mandatory and Swiss civil defense measures are considered among the best in the world. Certainly, they are far superior to Soviet measures.

Another nation which has consistently sought neutrality and which has a strong civil defense is Sweden, where the draft is used to provide civil defense manpower and shelters are required by law to be provided by local governments. A similarly elaborate program exists in West Germany. Here, the civil defense administration numbers well over a million persons, many times higher than the full-time civil defense cadres of the Soviet Union. Blast shelters are also required in certain localities. Denmark also has a significant civil defense program and Britain a somewhat less developed scheme; two more cases of nations which have felt the effects of foreign attack or occupation. And the Peoples Republic of China also has a population protection program in its urban centers.

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[38] For a summary of foreign civil defense programs, see "A Critique of Some Technical Aspects of Civil Defense," Appendix I (Washington, D.C.: Advisory Committee on Civil Defense, National Academy of Sciences, 1969). See also Elisabeth Crawford, "Civil Defense Programs in the Present World," Annex III to "Arms Control and Civil Defense," prepared by the Hudson Institute for the U.S. Arms Control and Disarmament Agency under contract ACDA/IR–10, August 20, 1963, pp. 1–3.

All of these programs like that in the Soviet Union, were undertaken in the early part of the nuclear age and were increased when thermonuclear weapons were married to medium- and long-range ballistic missiles. Given the advent of MIRV and the current levels of strategic destructive power, none of them would be proof against a determined attack by a nuclear super-power. Yet they could provide some protection against small scale nuclear conflict in Europe, especially if it was of short duration. Should any such conflict be restricted to conventional weaponry and not involve theater nuclear forces, the utility of these resources would be even greater. This, of course, holds equally true for the passive defense measures of the Soviet Union, since it is also vulnerable to attack by conventional weapons as the United States is not.

A detailed examination of the development and the effectiveness of Soviet passive defenses, in comparison with those of other countries and in comparison with developments in strategic and theater nuclear forces, provides a picture far less disturbing than that suggested by some observers. The Soviet efforts, it is clear, grew out of the World War II experience with strategic conventional bombing, as they did in other countries. These efforts were stimulated by the advent of medium- and long-range ballistic missiles, which were sufficiently inaccurate and few in number that passive defenses could provide a relatively effective "equalizer." In the meantime, however, the steady qualitative and quantitative advances in strategic weaponry, and especially the MIRV, have severely undercut the utility of passive defenses against a strategic nuclear strike. Nevertheless, these programs continue to have some effectiveness against smaller-yield, medium-range nuclear weapons such as both sides deploy in Europe. Likewise, they would continue to be effective against strategic attacks by relatively inaccurate, smaller-sized nuclear forces, such as those currently possessed by China or France. (While it appears unlikely that the Peoples Republic of China would launch a first strike on the comparatively superior forces of the Soviet Union, such an attack might come as a desperate response to a Soviet invasion of Chinese territory. In this event, the Soviet protective measures could substantially blunt the effects of this low-order Chinese attack.) Therefore, such programs will likely be continued not only by the Soviet Union but by other nations in Europe, East and West, and by China, because they continue to be effective against certain, limited threats, unique to Europe and Asia.

Finally, the non-strategic motivations suggested earlier will likely continue to play their role in reinforcing the willingness of the Soviet Union to commit appreciable resources to the defense of population and industrial machinery. In the absence of any feasible measures for protecting the many vulnerabilities in the Soviet economic system and in view of what even a partially successful nuclear attack would do to Russia's role as a great power, there appears to be no reason to suppose that the continuing commitment of resources to population protection and defense of heavy machinery could in time thwart a U.S. retaliatory attack.

Long-Term Physical Effects of Nuclear Exchanges

Many of the effects of nuclear weapons detonations can be projected with a reasonable degree of accuracy, given data on the type of burst (air or surface), type and yield of weapon(s), physical environment of the impacted area, proximity and exposure of structures or humans to the blast and other effects, and similar variables. Among the prompt effects which are susceptible of quantification or prediction within a tolerable range of error are the size of the crater and rupture zone, blast overpressure effects, thermal or burn effects, initial nuclear radiation effects and, to a lesser degree, secondary effects, such as crumbling of buildings, flying debris and glass, or fire storms and secondary fires (as from exploding gas mains).

Nuclear Radiation

There is a two-fold radiation hazard from nuclear blasts. Prompt or initial nuclear radiation is the product of a nuclear detonation that remains or decays near ground level. Radioactive fallout generally describes the radioactive material created and lifted into the atmosphere by the detonation, falling back to Earth over a wide area in a period ranging from ten hours to several years.

It is more difficult to shield against the effects of prompt nuclear radiation because of differing radiation intensities. The effects of prompt radiation and fallout radiation on humans vary with the dosage, degree of exposure, adequacy of medical care and other factors. Two examples of these effects, one illustrative and the other actual, are described in the following paragraphs.

The prompt nuclear radiation emitted in the first minute from the explosion of a one-megaton weapon would be at least 700 REM (roentgen equivalent mammal—the unit for measuring radiation doses to organisms) over a range of 1.5 miles. When exposed fully and rapidly to 600 REM, a group of people would become sick within four hours and over 50 percent of them would soon die.[39]

In 1954, the crew of a Japanese fishing vessel and the natives of Rongelap Atoll received heavy doses of fallout from the United States' Castle/Bravo nuclear weapon detonation at Bikini (largest ever by the U.S.) though they were 90 to 100 miles downwind of the burst point. The radiation poisoning had severe short- and long-term effects on these unintended victims, including serious build-ups of radioactive isotopes in the thyroid glands of those affected, especially children.[40]

The effects of nuclear radiation sickness include changes in blood formation, decreases in white blood cells, loss of natural immunity to infection and a high risk of secondary infection. These effects have been described in a 1962 Atomic Energy Commission publication edited by Samuel Glasstone and entitled *The Effects of Nuclear Weapons*. "The earliest symptoms of radiation injury are nausea and vomiting, which may commence 1–3 hours after exposure, accompanied by discomfort (malaise), loss of appetite and fatigue . . . Loss of hair will be apparent about 2 weeks or so after receipt of a dose

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[39] "Biological and Environmental Effects of Nuclear War," summary analysis of hearings before the Joint Committee on Atomic Energy, June 22–26, 1959 (Washington: Government Printing Office, August 1959), pp. 13–14.

[40] "Worldwide Effects of Nuclear War: Some Perspectives," a report of the U.S. Arms Control and Disarmament Agency (Washington, n.d.), pp. 4–5.

exceeding 300 rems . . . infections which could normally be dealt with by the body may prove fatal in such cases . . . Commencing 2–3 weeks after exposure, there is a tendency to bleed into various organs and small hemorrhages under the skin . . ."

Blast and Fire

At a radius of three miles from a one-megaton detonation, a brick apartment building would collapse from the blast wave. At a radius of nine miles kindling materials would ignite and and bare skin would be subject to second-degree burns as a result of heat radiation from the fireball.[41] Heat radiation will ignite more flammable materials tens of miles away.

Electromagnetic Pulse

Another predictable but less quantifiable series of effects are those which impact on electrical phenomena, such as power generation and communications. Nuclear detonations create an electromagnetic pulse (EMP) which can disrupt both power generation and distribution and communications systems in the immediate aftermath of an explosion.[42] High-altitude bursts can "black-out" high frequency (usually voice) communications for several hours as far as 600 miles from a nuclear burst by disruption of the ionosphere, which acts to reflect long-distance radiowaves back to the earth. Bursts below five megatons can produce belts of charged particles in the earth's magnetic field, causing the impairment or failure of satellites in low earth orbit.[43] Communications and satellite photography are, among other things, very important to early warning of and reaction to nuclear attack.

Social Effects

Other and more significant effects of nuclear attacks are much less easily quantified or projected, owing primarily to the large number of variables involved and the paucity of relevant data. Predictions about the impact of nuclear attacks on individual or group psychology and on social, economic, and political institutions, for example, tend to be highly speculative in nature, though a number of studies have examined the range of possibilities, frequently relying on data from the Hiroshima and Nagasaki bombings or other catastrophic events.[44]

Radioactive fallout

Similar uncertainties exist in connection with the long-range effects of radioactive fallout on plant and animal life, again as a result of very limited data on a very large number of significant variables or as a result of a host of assumptions which must be made as a basis for prediction. While scientists can project with some assurance the effects on man and animals of initial nuclear radiation under specified conditions of dosage, exposure, promptness of treatment, etc., predictions about long-term genetic and environmental effects must remain heavily qualified.

Ordinarily, where uncertainties are large, prudent military planning tends to make conservative assumptions and projections in order

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[41] "Biological and Environmental Effects of Nuclear War," op. cit. p. 15.
[42] See "Emergency Preparedness Progress in the Electric Utility Industry," op. cit.
[43] "Worldwide Effects of Nuclear War: Some Perspectives," op. cit., p. 5.
[44] See the previously cited works of Ikle, Vestermark, Lifton, and the Manhattan Engineer District.

to leave a significant margin of safety in the event the more harmful or damaging case occurs. In the area of radioactive fallout, however, there has generally been a persistent bias in favor of making the most optimistic calculations.

Soviet planners, for example, appear to be providing for fallout shelter water and food supplies of three to five days, although under certain conditions these shelters may have to be occupied for two weeks and, even if conditions permit short-term forays from these shelters, uncontaminated supplies of food and water may not be available outside. Likewise, Soviet measures against radioactive fallout appear to rely on a multi-purpose pill or tablet of uncertain utility.

In the United States there has been a continuing debate as to whether nuclear weapons policies should be based on pessimistic or optimistic calculations of the mid- and long-term effects of radioactive fallout.[45] The longevity of this debate is attributable to fundamental uncertainty as to whether a nuclear attack would or could be timed and configured so as to maximize or minimize fallout. Some of the factors involved in this kind of calculation, such as weapon yields and type of burst, are subject to human control. Other factors, such as prevailing winds and other climatological factors or the amount of radioactive debris carried into the atmosphere, are less susceptible of advance planning and control.

Many of the studies prepared for various military and civil defense authorities of the federal government have inclined toward the view that the initiator of a nuclear attack will have a strong incentive and ability to minimize radioactive fallout. The assumption of an incentive to minimize radioactive fallout is predicated on the idea that the mid- and long-term effects of heavy fallout would be counterproductive for all concerned. The assumption of a capability to minimize fallout appears to rest on the belief that the participants in a nuclear exchange would be able to time exchanges so as to account for factors such as winds and climate which, practically speaking, do not appear to be as manipulable as some planners assume.

Unless the participants are able to pinpoint the season, locale, and time of day for nuclear exchanges with considerable precision and unless meteorological data provide accurate predictions of conditions in or over attacked areas, efforts to limit local or worldwide fallout patterns will be highly error-prone. Likewise, the utility of post-attack measures (fallout shelters, decontamination measures, etc.) will vary considerably depending on the ability of the nuclear combatants to control these same factors.

Nevertheless, all studies of the matter in the United States appear to agree on two major points. After a large-scale nuclear exchange resulting in heavy radioactive fallout, most animal species, including the human race, will survive, in the southern hemisphere if not in the northern, and the environment, including the oceans and atmosphere, will return to a close approximation of its pre-attack condition within a period ranging from a decade to a quarter of a century. A 1969 study, for example, stated that "The recovery of disturbed natural ecosystems without assistance from man . . . is expected to take a much longer

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[45] In this connection see the various fallout contours under different attack and weather conditions postulated in "Analyses of Effects of Limited Nuclear War," a report of the Committee on Foreign Relations, U.S. Senate (Washington: Government Printing Office, July 1975).

time—more than a decade, if the disturbance is severe." [46] The question therefore is not whether there will be survival per se but what level of survival citizens and their leaders consider to be the minimum acceptable level. Since the survival of an organized society, a culture, or a political entity, together with its economic base, might be jeopardized by the long-term effects of radioactive fallout, their possible impact must be assessed by national leaders in nuclear policymaking and decisionmaking, along with the prompt effects of nuclear weapons detonations.

Two Studies

Two of the more well-known studies of the possible effects of large-scale nuclear exchanges are a 1959 effort made by the Joint Committee on Atomic Energy with the cooperation of a variety of government agencies and a 1975 study made for the Arms Control and Disarmament Agency by the National Academy of Sciences and entitled "Long-Term Worldwide Effects of Multiple Nuclear-Weapons Detonations." [47] The first study assumed a total detonation of 4,000 megatons of nuclear weapons in the northern hemisphere, while the latter assumed detonation of nuclear weapons yielding a total of 10,000 megatons. Carefully avoiding predictions as to social, political and most economic consequences and qualifying their conclusions with equal care, these studies suggest a range of possible effects indicating that radioactive fallout cannot be dismissed as a factor in calculating acceptable levels of survival.

Limits of Medical Care

The first mentioned study, for example, noted that 25 percent or 12.5 million of the anticipated 50 million United States fatalities in the hypothetical attack would result from fallout, while more than half of the 20 million serious casualties would suffer radiation injuries. Even if no medical care capacity were lost in such an attack, an immediate consequence of fallout casualties at or near this level would be the swamping of medical care facilities, both by fallout casualties and casualties from other nuclear weapons effects, such as thermal burns, prompt radiation or flying debris. The likely response to such an overwhelming number of casualties would be to restrict the provision of limited medical resources only to those who had the best chance of survival, so as to make these medical resources count the most. More seriously injured casualties, who might have injuries treatable under normal conditions, would have to be rejected. Fatality or casualty estimates which include only figures for prompt fatalities and casualties are misleading. They do not address the economic, military, or social impact of death and disease resulting from radiation sickness that takes several weeks to cause death or from later fallout-induced illnesses or from overtaxed medical facilities.

The social impact of this bleak medical situation cannot be gauged in advance but it is not unreasonable to assume that it would have

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[46] "A Critique of Some Technical Aspects of Civil Defense," by the Advisory Committee on Civil Defense of the National Academy of Sciences for the Director of the Office of Civil Defense (Washington: Department of Defense, 1969).

[47] This controversial study did not examine the effects of attacks on the attacked areas (assumed to be in the northern hemisphere) but only on the non-attacked areas and on the world-wide environment in general. Moreover, it examined each effect in isolation and not cumulatively.

very deleterious effects on an already impaired civilian morale. In recognition of the likely impossibility of being able to treat many fallout or other casualties for a lengthy period after a nuclear attack, the United States in the late 1950s began the stockpiling of large quantities of opium, so as to have available supplies of morphine for the temporary relief of casualties who could not be provided adequate medical attention in the post-attack period. At the same time, the need to provide medical services to a very large number of less seriously injured would impose a very large burden on surviving medical care facilities and personnel and on any post-attack economic recovery effort, by requiring the diversion of manufacturing capacity to medical equipment and materials.

Over the longer term, both studies agree, fallout would produce an increased incidence of leukemia and other types of cancer. Deaths from increased incidence of cancer would be spread over a period of two decades or more, since radiation-induced cancers are typically delayed for a long period after exposure or ingestion. Fallout-induced cancers and similar long-term radiation effects on man would not only decrease average life expectancy and increase mortality rates, they would impose a long-term burden on health care facilities because of the generally debilitating nature of cancers for extended periods before their hosts succumb to them.

In addition, according to the earlier study, "There is considerable evidence that the radiation exposure of a nuclear war would greatly increase genetic mutations for some succeeding generations." These mutations, it went on, would cause ". . . inevitable costs in physical impairments and deaths due to additional genetic mutations." The nature of such mutations and how they might be treated by post-attack society remain an unknown, of course, but, as the study points out, they would have to be regarded as an additional cost or burden of nuclear war.

Environmental Contamination

Environmental contamination presents perhaps even greater costs and burdens than the direct effects of fallout on human beings, owing to its more universal character. The harshness of the post-attack world will be amplified by the difficulties of coping with a number of possible effects of nuclear weapons detonations, including not only fallout but also depletion of the earth's ozone layer and other widespread effects. While many of these effects would be generalized to large areas, rather than limited to the countries of the nuclear combatants, they would be more severe in the combatant countries in some cases and would, in all cases, have certain consequences for the post-attack recovery of the combatants.

Food Supply

The most obvious and perhaps most serious such effect is the impact of fallout and ozone depletion on food supplies, especially if large numbers of humans survive through population defenses and place proportionally higher demands on the more limited food resources, which, for the most part, cannot be protected. This is a problem of considerable importance for nuclear war recovery and long-term survival.

Following a large-scale nuclear attack, large numbers of animals used for food in the attacked countries would be killed by exposure to fallout because they would not likely be provided with shelter during the exchange or soon afterwards. Though rapid slaughter of such animals and disposal of certain organs and milk would provide an immediate increase in the amount of flesh available for food, the long-term effect must necessarily be a substantial thinning of livestock herds and therefore a long-term net reduction in livestock products for human consumption, until such time as herds can be rebuilt to pre-attack levels. At the same time, increased incidences of animal disease resulting from decreased resistance through radiation exposure, coupled with an increase in genetic mutations in breeding stock, will make replenishment of livestock herds a more complicated and time-consuming process.

Already harvested or processed food, if contaminated by local fallout, may be decontaminated, depending on the amount of radioactive contamination, availability of decontamination materials, and the form the food is in. Of greater concern is the long-term effect of fallout on growing additional food supplies. Though many nuclear weapons will presumably be aimed at industrial areas, others will seek military or industrial targets located in food-producing areas. In addition, the peak fallout intensities rarely occur in the immediate vicinity of weapon detonation; rather, for a five- to ten-megaton detonation, the peak fallout intensity may be as far away as 60 to 70 miles from the point of burst. In zones of heavy local contamination, the soil would have to be decontaminated in order to decrease the level of strontium 90 content to a point safe enough to allow for the production of some edible food and milk. Given other imperative post-attack claims on resources, it may be impossible to carry out a program of soil decontamination in such areas and formerly productive fields and pasturage will have to lie idle and unproductive, thereby increasing demands on other agricultural lands and resources. Rainwater runoff from these areas may also affect plant and animal food chains, especially aquatic plants and animals, at some distance from local contamination.

Large-scale nuclear attacks also have a significant potential for affecting the availability of freshwater and saltwater food products, which, directly or indirectly (through fishmeal and fishoil for feed and fertilizer), form an important source of protein in both the U.S. and the U.S.S.R. The N.A.S. study, for example, examined the effect on the aquatic environment of ionizing radiation (from radionuclides), of ultraviolet radiation, and of climatic change, concluding that "If the upper limits of ozone depletion should be realized, irreversible injury to sensitive aquatic species might occur during the years of increase in uv–B [ultraviolet radiation] following the detonations." [48]

Global Impact

The same increases in ultraviolet radiation due to ozone depletion would have other consequences affecting various food chains and the availability of food generally:

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[48] "Long-Term Worldwide Effects of Multiple Nuclear Weapons Detonations," National Academy of Sciences, mimeo, 1975, p. 13.

> Depending on the actual magnitude of this effect [ozone depletion], which is limited to *the decade or two required for the ozone to be replaced* by normal stratospheric photochemical processes, there will have occurred during this interim more or less severe, worldwide effects on climate, crop production, mutagenesis of pathogenic viruses and microorganisms, as well as marked increase in the incidence of fatally intense sunburn, skin cancer, etc. [separate from cancers induced by fallout] . . . .
>
> However, the reader should be cautioned that this seemingly optimistic assessment, constructed by independently examining each of the specific elements noted above, has limited validity as an estimate even of long-term, worldwide effects. The committee deliberately refrained from synthesizing an integrated vision of this catastrophe.[49] [Emphasis added.]

A possible effect of both fallout radioactivity and ultraviolet radiation resulting from ozone layer depletion (besides increased cancers) is that they can reduce human and plant resistance to disease and infection. In areas where there are pools of disease-causing viral or bacteriological matter available, a general weakening of resistance could lead to epidemics or pandemics and to widespread curtailment of food production, especially if the radiation stimulates malign genetic changes in the pools of viral or bacteriological matter.

Weather itself may be directly affected by large-scale nuclear detonations, with attendant effects on food production. Though the N.A.S. study suggested that climatic effects from detonating 10,000 megatons (one-half of all nuclear weapons in present inventories) of nuclear weaponry might not create greater than normal climatic effects, it went on to state that:

> Considerable uncertainty is inherent in all predictions with respect to climatic change . . . Hence, one may not exclude the possibility of an unfavorable climatic change considerably greater than that explicitly contemplated in the report.[50]

In terms of the direct effects on agricultural production, the study made this assessment, with particular reference to the needs of unaffected countries:

> The United States and Canada have become the world's "breadbasket," producing about two thirds of all the grain and much of the other food that is available for shipment in international commerce. There is reason to believe that the dependence of other nations on grain grown in North America to feed their growing populations will become increasingly severe for many decades. Patently, were the United States and Canada involved [in the hypothetical nuclear exchange], these crops would be unavailable for an indefinite period after a nuclear exchange of the magnitude contemplated by this report—and the death toll due to starvation in the dependent regions must then rise accordingly.[51]

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[49] Ibid., p. 4 of forwarding letter.
[50] Ibid., p. 5 of forwarding letter.
[51] Ibid.

Left unsaid is the equally patent conclusion that involvement of the Soviet Union in the hypothetical nuclear exchange would mean the loss or reduction of Soviet grain harvests for a similar indefinite period, harvests which are already inadequate for Soviet needs.

Similar but more general conclusions were reached in a report of the N.A.S. study issued by its sponsor, the U.S. Arms Control and Disarmament Agency:

> Since 1970, an increasing fraction of the human race has been losing the battle for self-sufficiency in food, and must rely on heavy imports. A major disruption of agriculture and transportation in the grain-exporting and manufacturing countries could thus prove disastrous to countries importing food, farm machinery, and fertilizers—especially those which are already struggling with the threat of widespread starvation. Moreover, in virtually every economic area, from food and medicines to fuel and growth-engendering industries, the less-developed countries would find they could not rely on the "undamaged" remainder of the developed world for trade essentials: in the wake of a nuclear war the industrial powers directly involved would themselves have to compete for resources with those countries that today are described as "less developed."
>
> Similarly, the disruption of international communications—satellites, cables and even high frequency radio links—could be a major obstacle to international recovery efforts.[52]

While most studies indicate that the long-term effects of nuclear detonations, particularly fallout, would likely be less severe than the immediate or near-term effects of blast, initial radiation, fires, etc., it cannot be doubted that the long-term physical effects, even if not precisely predictable, portend serious consequences for the long-term social, economic, political and even cultural viability of an attacked society or nation. The converse of the conclusion just quoted is that the unaffected areas following a superpower nuclear exchange will themselves be deprived by the damage to the major powers and will have no surplus of resources with which to aid the recovery of the directly affected nations. This condition will further complicate the already severe problems of long-term social, economic, and political recovery. Indeed, the possibility cannot be discounted that the combination of immediate effects, long-term effects, and an absence of recovery resources in the non-affected areas will mean that recovery will take place over so long a period and will necessitate so many social and political changes that the result will bear no relation to today's world.

Of more practical significance, however, is the high probability that a nuclear exchange between the major nuclear powers will result not only in their own immediate impoverishment but in the increased impoverishment of the already less developed world, with serious consequences for whatever social and political stability exists at present. The circumstances under which this would be viewed as an acceptable consequence of nuclear war or would produce the judgment that one side had achieved a victory are difficult to imagine.

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[52] "Worldwide Effects of Nuclear War: Some Perspectives," op. cit., p. 23.

Though one may hope that nuclear war will not eventuate, that, if it occurs, it will not be on a large scale, or that, if on a large scale, it will not have the postulated short- and long-term consequences, no one can guarantee any of these hoped-for eventualities. In the meantime, prudence suggests that planning must take into account not only benign estimates of the effects of nuclear war but also the "worst case" estimates of these effects, both long- and short-term.

MINORITY VIEWS

Senator John Tower and Representatives Garry Brown and Chalmers Wylie join in this Minority Report.

The Report by the Joint Committee on civil and industrial defense and nuclear attack presents views to which we cannot fully subscribe.

Our criticism of the Report as endorsed by a majority of the Joint Committee centers on the three following points:

First, the Report takes a too narrow, shortsighted and, at times, inaccurate view of the strategic consequences of the combined effect of the recent and continuing build-up in Soviet civil defense and offensive power and their meaning as an extra dimension to options available to the Soviet Union. A likely reason for this error is that in numerous instances the Report seriously overstates the actual capability of U.S. strategic forces.[1]

Second, the Report in its analysis does not give due regard and weight to the possibility that industrial and civil preparedness measures available in the Soviet Union are an effective instrument for recovery and survival.[2]

Third, a most troubling aspect of the Report is the suggestion [3] that by launching a first strike against the Soviets, the effectiveness of their civil and industrial defenses could be nullified. The fact that a preemptive attack against the Soviet Union is proposed as the simplest way to overcome these defenses provides a stark example of the effect Soviet civil defense may have in limiting U.S. options.[4] Certainly we must retain as an alternative the launching of a first strike in the event of Soviet military aggression. But a preemptive attack must never become the only available option because of an asymmetry in strategic capabilities. To allow this to happen would place a hair trigger on nuclear war and would be inconsistent with the U.S. objective of deterring nuclear war.

This Minority report does not conclude that the United States should mirror the Soviet civil defense effort or find that the Soviet efforts have necessarily destabilized the strategic balance at the present time.

Rather, we conclude that while efforts within the Soviet Union to protect its people, industry and leaders may not at this time over-

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[1] For more detail on the first criticism see, Appendix to the Minority Report, p. 110, which is devoted to an analysis of the Majority Report's overstating of U.S. force capabilities.

[2] See part II, p. 10.

[3] See report pages 23–26, 52–53, and footnote 7, p. 24.

[4] Likewise, readoption of the countervalue or population targetting doctrine would be similarly severely limited as an option by an effective Soviet civil defense.

whelmingly advantage the Soviets, if present trends continue these efforts could become destabilizing.[5]

Our knowledge as to the meaning and effectiveness of Soviet civil defense is, at present, incomplete. A full understanding of these efforts, and their implications in assessing our own offensive and civil and industrial defense strategies is essential to our national security and requires that the highest priority be given to an examination of these critical issues.

I. *Strategic Consequences of Civil and Industrial Preparedness*

The issue of how we defend ourselves now and in the future is the essential question of whether we survive as a nation.

If a nuclear war between the superpowers ever occurred it would surely cause large-scale damage to the economies of both countries and cause, at a minimum, millions of deaths and casualties. It could cause destruction unprecedented in the history of mankind.

The recognition of this prospect has led decision-makers in this country to formulate a policy of deterrence whereby the United States seeks to prevent hostile actions against our interests by threatening a retaliation which would clearly outweigh any advantage that a potential enemy might hope to gain.

This has been the very basis of U.S. defense policy for over 25 years now and the principal requirement of this policy has been to insure that an American retaliation would be assured. By guaranteeing a devastating and unacceptable retaliation it was believed that no sane foreign decision-maker would undertake major actions inimical to U.S. interests.

This is still the basis of U.S. deterrence doctrine and the real question raised by Soviet civil and industrial preparedness is whether or not the Soviet Union remains convinced that the United States has the capability and the will to cause "unacceptable" devastation to the Soviet Union and its allies.

In 1972 the Soviet Union and the United States signed the Anti-Ballistic Missile Treaty. The United States viewed this Treaty as a sign that the Soviet Union had accepted the philosophy of mutual assured destruction—mutual vulnerability to retaliatory attack.

In effect, the people of both countries were to become hostages and a stable situation would ensue.

There is evidence, however, that this was not the case.[6] At the time of the signing of the ABM Treaty or shortly thereafter, the Soviets gave renewed emphasis to their civil defense program and since then there has been mounting evidence that the Soviet Union has continued

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[5] In the Annual Defense Department Report for Fiscal Year 1978, Secretary Rumsfeld recognized the potentialities that exist by noting at page 107:

"During the last six months we have become more aware of the magnitude of Soviet Civil Defense efforts, although major gaps in the intelligence data preclude us from making any confident judgments about effectiveness. What we see, however, suggests to us a continuing Soviet interest in enhancing the Soviet capability to survive a nuclear war, coupled with a steadfastness of purpose which is of concern.

"This civil defense capability—if it continues to grow as we expect—coupled with high-accuracy and more reliable missiles, could adversely affect our ability to implement the U.S. deterrent stategy. Thus, it could provide the Soviets with both a political and a military advantage in the event of a nuclear crisis."

[6] The report states at page 4 that no one "has, as yet, provided a satisfactory reason why the Soviet Union would deny itself active defenses by signing the ABM Treaty and then turn to less effective measures such as passive defenses." There is evidence that massive defenses are more effective, and more cost-effective, than anti-ballistic missile (ABM) defenses. In addition some analysts argue that the U.S.S.R. was very concerned about U.S. ABM capability and greatly desired to retard this effort in the SALT agreement.

to seek a damage-limiting or war survival program. Further, Soviet doctrinal statements and writings have never given any indication of acceptance of the theory of mutual vulnerability and, in fact, have given considerable evidence to the contrary. They have exhibited a belief that nuclear war is survivable and that should it occur, the Soviet Union will survive and recover.

Deterrence, then, does not depend on what U.S. analysts determine to be adequate levels for assured retaliation, but rather on what the Soviet leadership regard as being "unacceptable damage."

When the potentially effective Soviet passive defense programs is combined with the already extensive Soviet air defense and growing missile capabilities there is reason for concern over the underlying beliefs of the Soviet leadership. Do they believe that a nuclear war is survivable? Do they consider that civil defense increases the credibility of their deterrent, and, do they believe we thereby lose our ability to deter them? Why would the Soviet Union expend such a substantial amount of physical and financial resources to civil defense programs if they did not believe they may be potentially useful?

These are questions which should be answered. Absent a comprehensive investigation, we have no way of knowing how successful these Soviet efforts would be.[7]

It should be noted that the Joint Chiefs do not, in the above quote suggest that Soviet recovery from an attack would be paralyzed.

The issue of the effectiveness of civil and industrial preparedness is discussed in Part II of this report. In sum, this effectiveness would vary widely depending on the period of warning, weather conditions and size of the attack.

Civil defense for the Soviets, then is, at a minimum, a "hedge" against the failure of deterrence.[8] The United States must examine the credibility of our strategic deterrence by the same measure, i.e. in the event that deterrence fails.

Almost as important and more likely as a factor in destabilizing the world situation is the potential military and political effect of population protection in time of crisis. While the civil defense effort does not necessarily indicate a Soviet intention to deliberately resort to nuclear war, it may increase the willingness of the U.S.S.R. to exploit a crisis and possibly determine its outcome.

In a future period of tension and possible diminishing effectiveness of diplomacy, the U.S. President will be faced with a number of options. If the Soviets were to begin a major implementation of the protection plans through dispersal and sheltering in remote reception

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[7] The Joint Chiefs of Staff recently addressed the question of Soviet Civil Defense and its effectiveness. In the annex to a letter to Senator Proxmire from General George S. Brown, Chairman, Joint Chiefs of Staff, dated 28 January 1977 stated:

"The Soviet program is more extensive and better developed than it appeared to be several years ago. Under optimum conditions, which include a period of warning prior to an unrestrained U.S. attack and successful evacuation and other preparations, Soviet civil defense measures could probably: (1) assure survival of a large percentage of the leadership necessary to maintain control, (2) reduce prompt casualties among the urban population to a small percentage, and (3) give the Soviets a good chance to being able to distribute at least a subsistence level of supplies to the surviving population, although the economy as a whole would experience serious difficulties."

[8] The Report cites a number of officials' statements to the effect that the U.S. has a fully adequate deterrent capability. However, these statements were made prior to the re-examination of Soviet defenses which the Report admits did not begin until 1976. The Report failed to note the more recent official statements expressing serious concern, even though these statements were furnished for the record. (See Hearings, Joint Committee on Defense Production, November 18, 1976, Part I, pp. 175–178).

areas could even today severely limit the number of Presidential options.[9] The American people, if they were aware of the crisis and the Soviet evacuation of the cities might be less supportive of a President when he most needs their support during critical negotiations.

We fervently hope this rather brief scenario and others that could be imagined will not take place. But the extra dimension that the Soviets possess may make adventurism more attractive to them or, worse, successful.[10]

As noted above these views are not put forward to suggest that the U.S. immediately embark on a civil defense buildup similar to the Soviets or that they now have a civil and industrial defense capability that would enable them to substantially survive the destruction wrought by a nuclear attack.

However, in light of the available evidence (Soviet writings and doctrine as well as the statements of U.S. defense analysts), it must at least be granted that the Soviets may be striving for a war survival capability.

And, if they achieve this capability it could very well be dangerously destabilizing. This could lead to adventurism, to miscalculations on their part as to the consequences of certain actions and to their attempting to use political leverage in times of crisis.

If the Soviets perceive this happening, then something must be done. A variety of options have been suggested.

First, the U.S. might attempt to convince the Soviets that their defenses will not work. Second, we could match their efforts. Third, the U.S. negotiating team could introduce the question into the Strategic Arms Limitation Talks. And, fourth, as Secretary of Defense Harold Brown has suggested, we could improve the accuracy and yield of our missiles to offset their defense.

None of these options must necessarily be selected or excluded based on present knowledge but we must not ignore the problems or be lulled by a false sense of security for the future.

What the Soviets do to protect and preserve their people and industry is relevant to the strategic balance. If the Soviets continue to build their passive defenses and improve their missile capabilities as the evidence indicates they will, we may reach a point within the next 5 to 7 years where we will find that their efforts have destabilized the strategic arms balance. We must not wait for this to happen.

II. *The Effectiveness of Civil and Industrial Preparedness against Nuclear Attack*

Leaving aside, then, the question of the strategic consequences of the present and future situation let us turn to examine the Report's analysis of the possible effectiveness of civil and industrial preparedness.

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[9] The Report demonstates this limiting of options in a rather dramatic way by suggesting that "an American President, following a Soviet ultimatum might be swayed by public pressure to try a pre-emptive attack." (p. 24, footnote 7).

[10] For a discussion of this issue as well as a comprehensive review of the Soviet efforts, see Leon Goure, *War Survival in Soviet Strategy: U.S.S.R. Civil Defense*, Center for Advanced International Studies, University of Miami, 1976.

The only witness who appeared before the Joint Committee on the issue of effectiveness was Mr. T. K. Jones of Boeing Aerospace.[11] Mr. Jones has conducted a detailed analysis of Soviet industrial preparedness measures and similar measures applied to the U.S. aerospace industry. This study which involved live tests and a lengthy report to the Joint Committee found that the Soviet methods could permit rapid recovery of the U.S. aerospace industry in the event of nuclear attack.

In spite of this competent testimony that the Soviet protective methods could be highly effective, the approach taken in the Report of the Joint Committee was to seek reasons why such protective means might not work.

We did not need this Report to prove that if we set out to make civil defenses unworkable, we will never have effective protection for Americans. After all, the ability of Congress to make things not work is well established; this committee should avoid becoming a part of that problem. More important, as noted above, there is ample evidence that the Russians, instead of declaring civil defense difficulties to be insurmountable, are seeking solutions for them.

Evidence received by the Joint Committee indicates three considerations in seeking solutions to how industry and people can be prepared for a nuclear attack.

First, the U.S. and U.S.S.R. are capable of recovering from a nuclear attack.

In support of this consideration are a series of studies of postattack recovery which point to the conclusion that recovery would indeed occur. The most significant is the 1973 "PONAST II" study which was sponsored by the Joint Chiefs of Staff. An unclassified briefing on the PONAST ("Post Nuclear Attack") study states that one of the three main objectives of the study was to "assess the capability of the U.S. and U.S.S.R. to survive, continue the conflict, and recover."

The briefing continues that "although damage was awesome, both sides are calculated to have survived and to be capable of recovery. *This is the salient conclusion of the study.*" [12] (Emphasis supplied.)

Contrary to this evidence the Report suggests in several places that studies indicate that passive defenses would be of limited practicality, or would not be effective in the face of a heavy attack.[13]

The question, then, should not be limited to whether the U.S. and U.S.S.R. can survive a nuclear attack but rather the rapidity of recovery and how passive defenses can make this recovery more rapid.

The second important consideration is the effect that an increase in the survival of workers can have on the speed of this recovery. A view that population defense is not significant to war recovery does not give due regard to the testimony of Mr. Jones on November 17, 1976 and the study he provided to the Joint Committee. Mr. Jones' report at page 58 of the Joint Committee's hearings states:

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[11] Mr. Jones has made several appearances before Congress in addition to the Joint Committee. He most recently appeared before the Military Installations and Facilities Subcommittee of the House Armed Services Committee. His testimony and answers to questions for the record submitted March 4, 1977 are instructive.

[12] It should be noted that the PONAST II study's conclusions predated the 1976 knowledge of the massive Soviet build-up in civil defense.

[13] See pages 1, 13, 16–18.

> A number of studies done in the U.S. have examined the factors influencing industrial recovery of a nation following a nuclear attack. Taken collectively, the results indicate that survival of the work force is by far the most important factor in industrial recovery.

Mr. Jones goes on to note that "if one-half the work force were destroyed, recovery would take three times as long as it would take if half the capital assets were destroyed."

To simplify, these first two considerations indicate that recovery is an important element in survivability and that people not just machines are the measures of this recovery.

A third consideration of the effectiveness of civil defense is whether damage inflicted by a nuclear attack may be so unacceptable as to make recovery too slow and too painful. This consideration may be the ultimate question as it involves the calculated risk in confrontations which would lead to nuclear war. It is also the most uncertain of all considerations as we cannot know what is in the minds of Soviet leaders in calculating these risks, but rather we must rely on what indications of these calculations are available.

Added to this uncertainty of knowledge as to Soviet intent is the degree of damage that might be considered unacceptable by the U.S.

Finally, let us turn to an examination of assertions in the report which tend to be contradicted by or are inconsistent with other evidence. It is hoped that in doing so there might emerge an indication of the effectiveness of civil and industrial preparedness possibly as viewed by the Soviets in considering the "acceptability" of the risk of surviving a nuclear war.

The report asserts at pages 1, 16–18, 52–53, 55–56, 68–69, and elsewhere, that passive defenses of population or of industry can be "easily" overcome.

Evidence available to the Joint Committee demonstrates that "overcoming" population defenses in the face of Soviet evacuation of cities during a crisis is unlikely. This is supported by the JCS paper transmitted to Senator Proxmire on January 28, 1977 (that casualties among the Soviet urban population could be held to a small percentage), and by the testimony of Mr. T. K. Jones (that Soviet fatalities could be as low as 2 percent of the total population). Mr. Jones stated, in his answers to questions posed by the Joint Committee, that the estimate of 98 percent survival was based upon a number of assumptions which were, from the U.S. perspective, highly optimistic and represent what the Soviets would probably view as a worst case. For example, U.S. offensive forces were assumed to have survived well, and all surviving U.S. warheads were assumed to have been expended in a retaliatory strike on Soviet urban/industrial areas or on evacuation areas. Soviet defenses, by contrast, were stated as having been assessed conservatively.

The Report states that there is no evidence to suggest Soviet leaders feel their passive defenses would allow them to "evade" U.S. retaliation, and that it was not possible to confirm the "estimate made by some" that Soviet defenses would have more than "marginal, 'last resort' value" against a U.S. retaliatory attack. (at page 29.)

As for terms such as "evading" or "avoiding" damage (or finding "immunity") from U.S. retaliation, these are typical of the practice

found throughout the Report, of making absolutes out of matters which are in fact issues of degree. It should be clear, for example, that there is no clean break or discontinuity between "surviving" and not surviving, but that there is a highly significant difference between survival of 40 or 50 percent and 95 or 98 percent.

As for the ease of overcoming defenses aimed at protecting industry, Mr. Jones pointed out in his testimony that to overcome the effect of observed examples of Soviet industrial dispersal could require an eight-fold increase in megatonnage (Hearings, p. 71). Also, in answer to questions submitted for the record, Mr. Jones provided data showing that to overcome hardening measures using current SLBM warheads, as an example, could require a 22-fold to 43-fold increase (Hearings, p. 207) in numbers of U.S. warheads. Assuming Mr. Jones to be accurate in his computations, such increases in the U.S. arsenal are beyond what would be considered easy.

If plans, training, and materials were effective, Mr. Jones believes "Soviet industry could transition to a well protected posture within a 3-day period." If this were not the case, 4 to 6 weeks of concerted effort could be required. Hence, said Mr. Jones, "the issue is not whether they can protect their industry but how long it would take to transition to a protected posture."

The Report asserts that to function effectively, Soviet evacuation plans would require training and exercising of the general populace, and that without this, the predicted times for "complete evacuation would be considerably degraded and evacuation could be considered only a last resort, a measure to be relied on only in the most desperate circumstances." [on p. 84.]

Careful investigation of U.S. evacuation operations, required by hurricanes or other peacetime emergencies, suggests strongly that what is essential to effective evacuation is not rehearsal involving the public but rather exercises involving the key officials who would be responsible to conduct operations.[14] However, even if lack of rehearsals did somewhat extend the three days which the Soviets apparently believe would be needed for evacuation, this would not appear to be a major problem. As noted earlier, it appears highly likely that it would be the Soviets, not the U.S., who would be most nearly in control of the situation.

That Soviet evacuation might require, for example, five days or even a week instead of three days, does not of itself lead to the conclusion that evacuation thereby becomes a "last resort," for use only in "desperate circumstances." It is of course possible that Soviet leaders perceive evacuation in such vivid terms, and it would be interesting to ascertain what they might perceive as a last resort, or desperate circumstances. However, it does not seem that the nature of the Soviet perceptions would be solely or perhaps even primarily governed by whether they judged evacuation to require six as opposed to three days.

The Report seems to suggest that the same people who during the period October through December, 1941, evacuated 500 industrial enterprises from the Moscow area could not now evacuate because of

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[14] W. E. Strope, *Importance of Preparatory Measures in Disaster Evacuations*, SRI Project 4688, November 1975.

winter cold, spring planting, fall mud, and possible summer showers. In fact, the reverse is true. A detailed study done by the Stanford Research Institute concludes that evacuation is possible in the Soviet Union on all but a few days each year.[15]

One possible reason for these mis-estimates is that much of the Report is based on the high-cost, rather ineffective civil defense concepts of the 1960s. It is then asserted that protection technology has not changed. Perhaps the technology *per se* has not changed, but the Soviet concepts are radically different from the U.S. ideas of the 1960s. For this reason, the old conclusions are not relevant.

Moreover, the Report fails to recognize that the Soviet objective is rapid recovery rather than "protection" and that while refineries and rail yards may not be "protectable" they can be made rapidly recoverable. An appreciation of this distinction is particularly important because of the view in the Report (at page 52, and 56–57) that an attack on a critical segment of Soviet industry might cripple recovery.[16]

The Report states at page 21 that the inability of a nuclear aggressor to invade, conquer and occupy the territory of its adversary would result in a foe "far more resolute and determined in the future," a prospect which will deter the aggressor from attacking.

While an attractive thought, this prediction of an embittered and resolute foe appears to be at odds with other material a few pages earlier, which suggested that it would be difficult or impossible for a nation to "survive" a nuclear attack "in any meaningful sense of the term survival." It is not clear how a nation which had failed meaningfully to survive would be in a position, some years later, to turn upon their attackers.

The Report notes that shelters might have to be occupied for up to two weeks, and that studies during the 1960s "indicated a strong potential for group and individual breakdowns," resulting from such prolonged shelter confinement. (See Report page 50.)

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[15] *Ibid.*

[16] Mr. Jones, in his answers to questions for the record to the House Armed Services Subcommittee on Military Installations and Facilities submitted March 4, 1977, provided this analysis:

Question 6. Since we cannot, in your opinion, overpower Soviet civil defenses, could we not target critical segments of Soviet industry and its military, e.g. refineries, powerplants, etc. thus crippling Soviet recovery and as such reinstate the deterrent principle?

Answer. The question touches upon an important distinction: the difference between "disruption" and "recovery." It is clear that an attack on critical segments of Soviet industry would disrupt the economy. However, there appears to be no basis for the often-stated assumption that targeting "critical segments of Soviet industry" will cripple Soviet recovery. This assumption is not supported by historical studies nor is it supported by the theoretical studies on recovery that I am knowledgeable of. Traditionally, nations have instituted both product and factor substitution to such an extent that it has greatly attenuated the economic impact of military attacks against their industrial and logistics sectors. It was true for the Germans in World War II and more recently, for the North Vietnamese.

To address your question more specifically, we note that although refineries are large in size and relatively small in number, they can be rebuilt or replaced with less efficient refineries omitting some processes which can still meet the needs of the nation. To destroy the electric power generating capacity of a country would involve destroying not only the large power plants but also a vast number of smaller ones, including standby power units, as well as their transmission lines. The effective execution of such an attack against this large, dispersed system is judged to be ineffective (from a recovery point of view) against a system which has even rudimentary protection.

An attack on certain segments of Soviet industry, which are subjectively judged more critical than others, would cause widespread damage, shortages, disruption and undoubtedly an angry response in kind. However, such an attack would not be sufficient in itself to assure that the consequences are unacceptable or that these consequences could not be overcome in a relatively short period of time. It would be unwise to base the security of our nation on a deterrent hypothesis of damage to the so-called "critical" segments of industry when historical evidence refutes the effectiveness of this approach.

In fact, the Office of Civil Defense and other shelter occupancy experiments were highly affirmative as to the ability of citizens (of a wide range of ages and backgrounds) to undergo prolonged shelter confinement and emerge capable of carrying out necessary post-shelter activities.

III. *Recommendations*

The issues which the Joint Committee addressed during its hearings are of crucial importance to U.S. national security and global stability.

The United States should avoid the situation suggested in the majority report that the simplest recourse to Soviet provocation or to the execution of their civil defenses becomes to launch a preemptive attack on the Soviet Union. A primary national objective is, and must continue to be, avoidance of nuclear war. We propose that by far the most desirable way to do this, is through deterrence.

A credible retaliatory capability is the central principle of deterrence, whereas a policy of launch on warning, or preemptive attack, would promote instability by placing a hair trigger on nuclear war.

The Soviet civil defense program, in connection with their effort to achieve nuclear superiority, is a matter that demands that adequate resources be given to its examination as a matter of the highest national priority. It is recommended that this investigation of Soviet civil defense planning and preparation assess the effectiveness of their program and its implications for U.S. strategic policy.

It is also recommended that the United States, through its appropriate departments and agencies and in coordination with the appropriate congressional committees, expand on the studies undertaken to date to assure a position of strength in U.S. postattack recovery.

APPENDIX TO THE MINORITY REPORT

A difficulty in accepting this Report is its frequent inaccuracies in stating U.S. force capabilities. This overstating of the capabilities of our weapons appears to be the reason for the Report's underestimate of Soviet civil defense capabilities.

As the jurisdiction of the Joint Committee on Defense Production does not normally encompass U.S. strategic force capabilities, this may be understandable. Following is a summary of some of the inaccuracies that in our opinion detract from the Joint Committee's Report.

—The Report overstates the U.S. advantage in one indicator of the strategic equation—warheads. Page 61 of the DOD Annual Report for FY 78 shows that the United States will have lost almost all of its warhead advantage by 1982.

—Many of the conclusions drawn in the report rest on the presumed capabilities of the U.S. SLBM force. The submarines are said to be "invulnerable" over an extended period of time, permitting the U.S. to attack Soviet Union urban centers after the evacuees had returned. However, the DOD has not made such claims for this force. It is known that the submarines would, in no more than a couple of months need to be reprovisioned and that they would be highly vulnerable at that time. Moreover, the command and control and reconnaissance assets needed for effective use of such forces do not have long-term survivability. The Report seriously overstates the retaliatory capability of the submarine weapons. Data submitted in response to the committee's request shows that 2500 SLBM warheads targeted against industrial installations in the top eleven Soviet cities would damage only about 10% of Soviet production and might destroy 349,000 workers. The Soviets could compensate by merely shifting the workers to factories in other areas of the country. (See Hearings, Part I, page 183).

—The table on page 13 attributes to the B–52 force about 5 times more SRAM missiles than have ever been procured for that force. The table ignores the Soviet Backfire which, even without refuelling and even using the lowest projections could add about one thousand warheads to the Soviet side of the ledger.

The report also claims that the Pershing missile is a threat to the Soviet Union when that missile can barely reach the distance from the eastern border of the Federal Republic of Germany to the Soviet border.

—The U.S., moreover, does not have the capability claimed by the Report, to target Soviet underground factories since we know the location of few of these installations. Nor can we expect to have surviving the reconnaissance assets to permit targeting of the Soviet factories relocated in the early stages of a crisis.

—It is claimed that Soviet industrial shelters (which are generally located around the periphery of the factories) would be destroyed if the factory was targeted. In fact, a U.S. sea-based warhead detonated over the center of a rather small Soviet factory would not destroy the underground shelters to the extent required. It is claimed that "the primary benefit of Soviet protection measures is to reduce the damage to non-targeted industrial facilities" (p. 81). In fact, a U.S. SLBM warhead targeted against a medium-sized, unprotected factory could be expected to destroy about half of the machinery while with the protection levels demonstrated in the study conducted by the Boeing Aerospace Company, p. 207, Hearings, November 18, 1976, it could destroy only 5% of the machinery.

—The Report asserts that the Soviet factory area shelters are ineffective because they are vulnerable to "direct hits", even though no nation has weapons that can reliably score direct hits.

—The Report also seriously overstates the capability of the "7000 nuclear weapons" in Europe and the thousand in the Atlantic fleet. Only a few of these are capable of being delivered against the Soviet Union (most are artillery shells, torpedoes and mines). The remainder are highly vulnerable and to attack Soviet targets must penetrate what are recognized as the heaviest air defenses in the world. Moreover, since those tactical nuclear weapons capable of delivery against the Soviet Union are based on European airfields and on aircraft, they do not have the very long term survivability claimed by the Report. Instead, military analysts agree that these bases and aircraft are not likely to survive for more than a few hours into a full-scale nuclear war with the Soviet Union.

—U.S. missiles are credited with "extremely high accuracy" and the capability to kill Soviet ICBMs not used in the initial attack. However the fact is that U.S. missiles now have neither the required accuracy nor yield to launch a counterforce attack that could destroy a significant portion of the Soviet ICBM force.

ADDITIONAL VIEWS OF SENATOR EDWARD W. BROOKE

Part II of the Joint Committee's report on Civil Preparedness is, indeed, a useful document setting forth many of the areas of primary inquiry regarding industrial defense against nuclear attack. Yet it is much more than this in that its emphasis on examining the issue in terms of deterrence thinking, nuclear war-fighting and weapons capabilities extends the scope of inquiry beyond what is commonly assumed to be the purview of the Joint Committee. In essence, Part II is a statement of policy regarding deterrence strategy on the part of the Joint Committee. And while there is much I can agree with in the report, I am not prepared to endorse it as a statement of policy accurately reflecting my views on many of the complexities of deterrence/defense thinking.

I also believe Part II is far too assertive in its conclusions in light of the unresolved controversies that characterize many of the subject areas it covers. The minority views of Senator Tower, Congressman Brown and Congressman Wylie set forth in some detail these areas of controversy and I shall not restate them here.

Perhaps the greatest weakness of Part II, as a policy statement, is its implicit discounting, without offering cogent evidence for doing so, of the possibility that the Soviet Union may be proceeding with a fairly significant civil defense program as part of a general attempt to achieve some form of political/strategic advantage by creating the perception of an asymmetrical security situation between the two superpowers favorable to itself. One possible goal of such an approach would be to influence third parties to concede a position of ascendancy to the Soviet Union as the "correlation of forces," to use a Soviet phrase, was perceived as shifting more and more in favor of Moscow.

I do not subscribe to the view that Moscow has a master plan for world dominance, nor do I believe that objectively the Soviets can achieve military superiority so long as we maintain a vigilant defense posture. But this does not negate the possibility that many Soviet leaders may be operating on assumptions different than our own. Soviet military writings and the SALT negotiation experience provide some evidence that this may be the case. If the Soviets do believe that military superiority can be achieved and translated into some form of positive political benefit, then we have to compensate for that belief as well as for the objective factors in the strategic equation. In this regard I believe there is sufficient cause for one to pause and reflect upon the possible linkage of the dynamic Soviet military buildup and continued Soviet efforts in the civil defense area as part of a possible Soviet process attempting to create a perception of ascendancy.

I could understand why Part II of the Committee report did not address itself to such "perceptual issues" if it had also foresworn speculating on the relationship between other theoretical factors and the industrial defense issue. Perception considerations are the most complex and ambiguous subjects relating to security matters. However, failure to address them while discussing many of the other "theoretical factors" relevant to examination of industrial defense and nuclear strategy is a serious oversight. It suggests that the intent of Part II may be to foster a certain persuasion rather than present an objective analysis of all factors relevant to the subject matter. In essence, having ventured into the realm of the interrelationship between civil defense efforts and nuclear strategy, Part II only goes far enough to substantiate a point of view rather than present the total range of considerations necessary for informed judgement.

Having pointed out some of the areas where I believe Part II is inadequate as a policy statement, I, nevertheless, believe that the conclusions it reaches that Soviet civil defense measures can objectively be circumvented in a deterrence sense by periodic adjustments in U.S. targeting plans and that an attempt by the United States to match Soviet civil defense efforts would not be advisable are essentially correct. However, what is necessary to successfully meet the challenge in the perceptual realm is an open issue deserving much greater attention by both the Congress and the Administration than it has been given to date.

EDWARD W. BROOKE.

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